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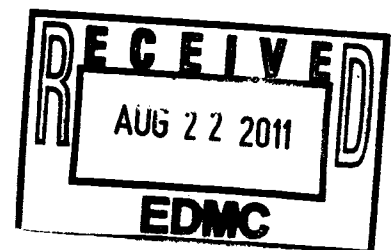
# Calendar Year 2010 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump-and-Treat Operations, and 100-NR-2 Groundwater Remediation

Prepared for the U.S. Department of Energy  
Assistant Secretary for Environmental Management



Richland Operations  
Office

P.O. Box 550  
Richland, Washington 99352



Approved for Public Release:  
Further Dissemination Unlimited

100-HR-3, 100-KR-4  
100-NR-2

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## Executive Summary

Interim remedies are operating in the 100-HR-3, 100-KR-4, and 100-NR-2 Groundwater Operable Units (OUs). Hexavalent chromium is the primary contaminant of concern (COC) in the 100-HR-3 and 100-KR-4 OUs; the hexavalent chromium is being treated by pump-and-treat (P&T) systems at these two OUs. The P&T systems extract groundwater and remove the chromium with ion-exchange resin in treatment plants prior to injecting the treated water back into the aquifer. At the 100-HR-3 OU, a permeable reactive barrier (PRB) is also used for in situ treatment of hexavalent chromium. This passive system reduces hexavalent chromium to the immobile, non-toxic trivalent form as it flows through a zone in the aquifer that is treated with sodium dithionite. In the 100-NR-2 OU, the COC is strontium-90. A P&T system developed for strontium-90 proved to be ineffective; subsequently, a PRB was installed to treat the aquifer with the mineral apatite, which reacts with the strontium to immobilize it within the aquifer.

This annual summary report describes operations and results of these remedies during calendar year (CY) 2010. The goals of the remedies are to protect the Columbia River, protect human health and aquatic life, and provide information that will enhance the remedy. The timeline is to meet the ambient water quality standard for hexavalent chromium in the hyporheic zone in the 100-HR-3 and 100-KR-4 OUs by 2012, the ambient water quality standard for strontium-90 in the hyporheic zone in the 100-NR-2 OU by 2016, and the Washington State drinking water standard for interior groundwater by 2020.

This report describes, in detail, the volumes of water treated, the amount of mass removed from the P&T systems, the P&T systems' efficiencies, and the resulting impact on groundwater concentrations. These interim remedies were initially implemented in the mid-1990s based on the understanding of the nature and extent of contamination at that time. Since then, through implementation of the interim remedies, the understanding of the nature and extent of groundwater contamination has improved significantly. In 2006, based on *The Second CERCLA Five-Year Review Report for the Hanford Site* (DOE/RL-2006-20)<sup>1</sup>, planning was initiated to expand the treatment systems to provide

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<sup>1</sup> DOE/RL-2006-20, 2006, *The Second CERCLA Five-Year Review Report for the Hanford Site*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

comprehensive treatment of the plumes in the aquifer. Expanded capacity has been installed, or is currently being installed, at all three OUs.

A significant amount of water was treated and mass removed from the aquifer during CY 2010, as follows:

- At the 100-HR-3 OU, treatment capacity was expanded to 3,160 L/min (835 gpm) near the end of CY 2010 with the addition of the DX system in December. A total of approximately 454 million L (120 million gal) of groundwater were treated, removing 105 kg of hexavalent chromium, primarily using the old systems.
- The PRB at the 100-D Area continued to operate; much of the barrier works well but a portion of the barrier is not effective.
- Treatment capacity is 4,164 L/min (1,100 gpm) at the 100-KR-4 OU. During CY 2010, 733 million L (430 million gal) of groundwater were treated removing 101 kg of hexavalent chromium.
- The PRB at the 100-NR-2 continued to remove strontium-90 out of solution, and groundwater concentrations have been reduced by 90 percent from pre-treatment conditions.

Continued work is required to monitor the interim remedies and to continue optimization of the treatment system as new information becomes available. Expanded treatment capacity has been added in recent years, including the KW P&T system expansion and KX addition in the 100-K Area, and lengthening the PRB at the 100-N Area through current work on expanded treatment at the 100-H Area.

While the treatment capacities now appear to be commensurate with the current understanding of plume sizes and geometry, operational effectiveness will be assessed to adjust extraction and injection well flow rates and to identify locations for new wells or supplemental technologies as trouble spots arise.

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## Terms

CERCLA	<i>Comprehensive Environmental Response, Compensation, and Liability Act of 1980</i>
CEM	capture efficiency map
CFM	capture frequency map
CHPRC	CH2M HILL Plateau Remediation Company
COC	contaminant of concern
CY	calendar year
DO	dissolved oxygen
DOE	U.S. Department of Energy
DWS	drinking water standard
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FS	feasibility study
FY	fiscal year
ISRM	In Situ Redox Manipulation
IX	ion exchange
MCL	maximum contaminant level
MDL	minimum detection limit
MTCA	<i>Model Toxics Control Act</i>
NA	not available
NTU	nephelometric turbidity unit
ORP	oxidation-reduction potential
OU	operable unit
P&T	pump-and-treat
PNNL	Pacific Northwest National Laboratory
PRB	permeable reactive barrier
RAO	remedial action objective
RCRA	<i>Resource Conservation and Recovery Act of 1976</i>
RI	remedial investigation

ROD	Record of Decision
RPD	relative percent difference
RPO	remedial process optimization
RUM	Ringold Formation upper mud (unit)
TBD	to be determined
TCE	trichloroethene
TPH	total petroleum hydrocarbon
Tri-Party Agreement	<i>Hanford Federal Facility Agreement and Consent Order</i>
UPR	unplanned release
WCH	Washington Closure Hanford

## 1 Introduction

CH2M Hill Plateau Remediation Company (CHPRC) is currently operating and maintaining five ion-exchange (IX) pump and treat (P&T) systems and two permeable reactive barriers (PRBs) as part of ongoing efforts to remediate contaminated groundwater in the Hanford Site's 100-K, 100-N, 100-D, and 100-H Areas (Figure 1-1). Two of the five P&T systems operating during calendar year (CY) 2010 were used to remediate hexavalent chromium in the 100-HR-3 Groundwater Operable Unit (OU), located within the combined 100-D and 100-H Areas. In addition, an In Situ Redox Manipulation (ISRM) PRB, located in the southwestern portion of the 100-D Area, continued to effectively remove hexavalent chromium contamination from groundwater during CY 2010. Three IX P&T systems were operated during CY 2010 to remediate hexavalent chromium groundwater contamination within the 100-KR-4 OU.

The interim actions being conducted to remediate groundwater at the 100-HR-3 OU and the 100-KR-4 OU are part of the effort to achieve the following three interim remedial action objectives (RAOs), as described in the Record of Decision (ROD) (EPA/ROD/R10-96/134, *Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units Interim Remedial Actions, Hanford Site, Benton County, Washington*).

- **RAO #1:** Protect aquatic receptors in the river bottom substrate from contaminants in groundwater entering the Columbia River.
- **RAO #2:** Protect human health by preventing exposure to contaminants in the groundwater.
- **RAO #3:** Provide information that will lead to a final remedy.

Unlike the 100-HR-3 and 100-KR-4 OUs, the primary contaminant of concern (COC) in 100-NR-2 OU groundwater is strontium-90. The interim remedial action initially chosen for the 100-NR-2 OU was P&T using an IX medium to remove strontium-90. In 2005, the RAOs were reviewed and it was determined that the P&T system was ineffective and inefficient in reducing the flux of strontium-90 to the Columbia River. In accordance with the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al., 1989), the 100-NR-2 P&T system was placed in cold-standby status on March 9, 2006, in accordance with Tri-Party Agreement Milestone M-16-06-01 ("Complete a Permeable Reactive Barrier [PRB] at 100-N"). The U.S. Department of Energy (DOE) began emplacement of a PRB along the 100-N Area shoreline in 2007 with the goal of sequestering strontium-90 in the aquifer (DOE/RL-2005-96, *Strontium-90 Treatability Test Plan for the 100-NR-2 Groundwater Operable Unit*). The progress on the barrier and other strontium-90 treatment technology tests is reported in this document.

The three RAOs from the current interim ROD (*Amended Record of Decision, Decision Summary and Responsiveness Summary, U.S. Department of Energy 100-NR-1 and NR-2 Operable Units, Hanford Site – 100 Area, Benton County, Washington* [EPA et al., 2010]) are listed below. The remedial technology implemented uses apatite as a reactive material to sequester strontium-90 from the groundwater.

- **RAO #1:** Maintain beneficial uses of the Columbia River and aquifer by reducing contaminant concentrations in 100-NR-2 OU groundwater.
- **RAO #2:** Obtain information to evaluate technologies for strontium-90 removal and evaluate ecological receptor impacts from contaminated groundwater.
- **RAO #3:** Prevent destruction of sensitive wildlife habitat. Minimize disruption of cultural resources and wildlife habitat in general and prevent adverse impacts to cultural resources and threatened or endangered species.

Target Tri-Party Agreement milestones have been established to ensure that the impact of hexavalent chromium and other contaminants to the Columbia River and groundwater are remediated in a timely manner. Three milestones directly applicable to the 100 Area OUs are as follows:

- **Milestone M-016-110-TO1 (December 31, 2012):** DOE shall take actions necessary to contain or remediate hexavalent chromium groundwater plumes in each of the 100 Area NPL [National Priority List] Operable Units such that ambient water quality standards for hexavalent chromium are achieved in the hyporheic zone and river column water.
- **Milestone M-016-110-TO2 (December 31, 2020):** DOE shall take actions necessary to remediate hexavalent chromium groundwater plumes such that hexavalent chromium will meet drinking water standards in each of the 100 Area NPL Operable Units.
- **Milestone M-016-110-TO3 (December 31, 2016):** DOE shall take actions to contain the strontium-90 plume at 100-NR-2 Operable Unit such that the default ambient water quality standard (8 pCi/L) is achieved in the hyporheic zone and river water column.
- **Milestone M-016-110-TO4 (December 31, 2016):** DOE shall implement remedial actions selected in all 100 Area Records of Decision for Groundwater Operable Units so that no contamination above drinking water standards enters the Columbia River unless otherwise specified in a CERCLA decision.

This annual summary report discusses the groundwater remedial actions conducted during CY 2010 in the 100-HR-3, 100-KR-4, and 100-NR-2 OUs. Chapter 2 discusses the 100-HR-3 OU, Chapter 3 discusses the 100-KR-4 OU, and Chapter 4 discusses the 100-NR-2 OU. An evaluation of costs is presented in Chapter 5, and the references cited in this report are included in Chapter 6. Additional supporting information is included in the following appendices:

- Appendix A, Major Ion Groundwater Chemistry
- Appendix B, Site History
- Appendix C, Methods and Results of Capture Zone Modeling
- Appendix D, Quality Assurance/Quality Control

## 1.1 Summary of Operable Unit Activities

Active interim action remediation continued during 2010 in the OUs, as well as initiation of remedial investigation (RI)/feasibility studies (FSs) leading to new RODs and future implementation of final remedies. An overview of these activities is provided in this chapter, and detailed discussions for each OU are provided in Chapters 2 through 4.

A stop work was issued in the fall of 2010 for groundwater sampling to address potential safety issues resulting from chemical odors in wells. Therefore, the sampling density for fall 2010 is less than previous years. Details are presented for each OU on the impact of these sampling issues. Overall, this had limited impact on analyses of the remedy effectiveness.

## 1.2 100-HR-3 Operable Unit Activities

The following subsections provide a brief summary of the activities at the 100-HR-3 OU for the reporting period.

### 1.2.1 100-HR-3 Operable Unit Pump-and-Treat Systems

Hexavalent chromium is the principal COC in groundwater. New wells have helped to define the extent of the hexavalent chromium plume, with concentrations over 69,000 µg/L in one well in the south 100-D Area plume that range from large areas and less than 100 µg/L in a local area across the OU.

In CY 2010, three *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) interim action remedies operated in the 100-HR-3 OU. These included the original HR-3 P&T system in the 100-H Area, which treats groundwater from both the 100-D and 100-H Areas; the DR-5 P&T system in the 100-D Area; and the ISRM barrier, which is also in the 100-D Area. The new DX P&T system entered acceptance testing late in 2010.

The DR-5 and HR-3 P&T systems continued to operate at normal capacity of approximately 132 and 757 L/min (approximately 35 and 200 gpm), respectively. The two P&T systems removed a combined total of 105 kg of hexavalent chromium from the 100-HR-3 OU in CY 2010.

The size of the 100-H Area hexavalent chromium plume has been significantly reduced since startup of P&T operations in 1997. A relatively smaller and lower concentration hexavalent chromium plume remains adjacent to the Columbia River, particularly to the north of the remediated zone. In contrast, the size of the 100-D Area hexavalent chromium plume has not been affected significantly by P&T operations. The new DX and HX P&T systems will help facilitate remediation efforts by expanding the capture zone in the 100-D and 100-H Areas, and for the first time in the horn area.

### 1.2.2 In Situ Redox Manipulation

In 2000, additional cleanup action was taken using an in situ chemical treatment technology, ISRM. Use of this new technology was approved by the 1999 interim ROD amendment (EPA/AMD/R10-00/122, *Interim Remedial Action Record of Decision Amendment for the 100-HR-3 Operable Unit, Hanford Site, Benton County, Washington*). Rather than pumping contaminated groundwater to the surface for treatment, this technology treats the groundwater in the aquifer by reducing the hexavalent chromium to trivalent chromium, which is a much less toxic and less mobile form.

The ISRM barrier continued to convert hexavalent chromium to a nontoxic, immobile form (trivalent chromium) within a portion of the aquifer. Concentrations in some downgradient wells remained above the remedial action goal of 20 µg/L due to the northeast segment of the barrier not working effectively; therefore, new DX extraction wells were installed downgradient of the barrier to treat this area. The ISRM treatment technology and its effectiveness are discussed in more detail in Section 2.3.4.

### 1.2.3 Remedial Investigation/Feasibility Study Activities

An RI/FS is being conducted to support the final ROD for the 100-D and 100-H Areas. Characterization activities began in CY 2009, as described in *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan, Addendum 1: 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units* (DOE/RL-2008-46-ADD1) and implemented through the *Sampling and Analysis Plan for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units Remedial Investigation/Feasibility Study* (DOE/RL-2009-40). The RI/FS addresses contaminant sources (e.g., site history), contaminant flow and transport, and exposure assessment, and it also supports risk characterization, remedial action selection, performance monitoring, and site closure. Data gaps have been identified and are currently being addressed through additional data collection and other investigations that will support final remediation decisions. A series of 15 monitoring wells, 10 vadose zone boreholes, and 5 test pits constitute the subsurface characterization activities. The field work is scheduled to be completed by May 2011.

### 1.2.4 Remedial Process Optimization Activities

A remedial process optimization (RPO) study began in 2008 to determine how to optimize the remediation of hexavalent chromium in 100-HR-3 OU groundwater by 2012 (SGW-38338, *Remedial Process Optimization for the 100-D Area Technical Memorandum Document*). The RPO review recommended increasing P&T system capacity and production to address the hexavalent chromium groundwater concentrations that still exceed the cleanup levels established in the interim ROD and interim ROD amendment (EPA/AMD/R10-00/122). Increased capacity is being implemented at both 100-D and 100-H Areas. The new expanded DX and HX P&T systems will substantially increase the rate of groundwater cleanup in the 100-HR-3 OU. Seventy RPO extraction/injection wells have been installed in the 100-HR-3 OU to further aid in groundwater remediation activities. Operational testing of the DX system (2,300 L/min [600 gpm]) began in December 2010. The HX system (3,000 L/min [800 gpm]) is scheduled to go online by December 2011.

During CY 2010, the DX P&T facility was completed, and operations began at the end of the reporting period. In December 2010, the DX system treated an additional 55.3 million L (14.6 million gal) of groundwater, with 18.4 kg of hexavalent chromium removed. The DR-5 system is being prepared for shutdown and its wells will be realigned to the DX P&T system. The HR-3 system will also be shut down for realignment of its wells to the HX P&T system.

## 1.3 100-KR-4 Operable Unit Activities

The following subsections provide a brief summary of activities at the 100-KR-4 OU for the reporting period.

### 1.3.1 100-KR-4 Operable Unit Pump-and-Treat Systems

Three active systems continued to operate at the 100-KR-4 OU during CY 2010. The KR4 system treats groundwater downgradient of the 116-K-2 Trench and has a treatment capacity of 1,136 L/min (300 gpm). This system operated for the first three quarters of CY 2010 before it was shut down for upgrades to the process logic control system. The KX system treats groundwater between the 116-K-2 Trench and the N Reactor area, as well as a plume downgradient of the KE Reactor. The KX system has a treatment capacity of 2,300 L/min (600 gpm). The KW P&T system extracts groundwater from around the KW Reactor facility and has a treatment capacity of 757 L/min (200 gpm). The combined systems treated 733 million L (430 million gal) and removed 101 kg of hexavalent chromium during CY 2010.

### 1.3.2 Remedial Investigation/Feasibility Study Activities

Characterization activities began in CY 2010, as described in the *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan Addendum 2: 100-KR-1, 100-KR-2, and 100-KR-4 Operable Units* (DOE/RL-2008-46-ADD2) and implemented through the *Sampling and Analysis Plan for the 100-K Decision Unit Remedial Investigation/Feasibility Study* (DOE/RL-2009-41). A drilling program of 13 wells and 2 boreholes was initiated in May 2010 and was approximately 80 percent complete by the end of CY 2010. The drilling campaign will be completed in the first quarter of CY 2011. Groundwater and vadose zone sampling at 1.5 m (5 ft) intervals was specified for many of the borings. Screen placement in the final well design is based on the vertical profile for hexavalent chromium in groundwater wells. Preparation of the RI/FS report began in CY 2010, with the report scheduled for completion in CY 2011.

### 1.3.3 Remedial Process Optimization Activities

The RPO studies to improve the effectiveness of remediation and meet target milestones were initiated in CY 2009 and carried over into CY 2010. Extensive groundwater modeling (through repeated updates as soil and aquifer data became available) has been used to design the treatment systems, relying on P&T and on combined bioremediation/P&T approaches. Modeling has guided Phases 1 and 2 and the well realignments between treatment systems, and it is supporting well drilling for Phases 3 and 4. Phase 3 drilling, which will be implemented in CY 2011, consists of four new wells drilled in key areas within the KR4 and KW plume area. Phase 4 drilling will be consistent with the final remedy selected in the RI/FS currently in process for the 100-K Area OUs, with ROD issuance anticipated by 2012.

## 1.4 100-NR-2 Operable Unit Activities

The following subsections provide a brief summary of activities at the 100-NR-2 OU for the reporting period.

### 1.4.1 100-NR-2 Operable Unit Pump-and-Treat System

The 100-N Area P&T system was placed in cold-standby status in March 2006. Contaminant concentrations have been tracked to quantify the effect on groundwater and recovery of the water table to pre-pumping conditions.

### 1.4.2 100-NR-2 Operable Unit Permeable Reactive Barrier

Under the existing interim ROD (EPA/ROD/R10-99/112, *Interim Action Record of Decision for the U.S. Department of Energy Hanford 100-NR-1 and 100-NR-2 Operable Units Interim Remedial Actions*) and Tri-Party Agreement Change Control Form M-16-06-01, the DOE agreed to construct and evaluate the effectiveness of a PRB for strontium-90 using apatite sequestration technology as part of the CERCLA RI/FS process. From 2006 through 2008, the first apatite PRB was installed along 91.5 m (300 ft) of the most contaminated section of 100-N Area shoreline. Since 2008, this section has been in performance monitoring to track the formation of apatite within the vadose zone and groundwater and to determine the effectiveness of the PRB in attenuating strontium-90 and preventing its release to the Columbia River. To date, the PRB has shown a 90 percent reduction of strontium-90 concentrations at the river's edge (PNNL-19572, *100-NR-2 Apatite Treatability Test: High-Concentration Calcium-Citrate-Phosphate Solution Injection for In Situ Strontium-90 Immobilization*). In response to the success of the existing PRB, 146 new injection and 25 new monitoring wells were drilled and installed along the remainder of the 100-N Area shoreline both upriver and downriver of the existing PRB. The PRB expansion will increase the barrier along the entire length of the contaminated portion of the 100-N Area shoreline (approximately 762 m [2,500 ft]). Current plans are for expansion 91.5 m (300 ft) both upriver and downriver of the existing PRB.

A jet injection study was also performed in the vadose zone upriver of the existing PRB in December 2009. Core samples were taken during drilling of the new PRB wells, both in the existing PRB and in the jet injection test sites, to look for the physical presence of apatite in the vadose zone and groundwater and to test the amount of strontium-90 incorporated into the apatite mineral matrix. A "cold" (noncontaminated) test of phytoextraction technology for removing strontium-90 in the riparian zone was completed at the 100-K Area in 2009. Preparations for testing the technology along the 100-N Area shoreline in the existing apatite PRB began in 2010. A draft treatability test plan for studying phytoextraction in a contaminated portion of the existing apatite PRB is currently under review with possible implementation at a later date. In the fall of 2010, Pacific Northwest National Laboratory (PNNL) conducted a test of an infiltration gallery just downstream of the existing PRB.

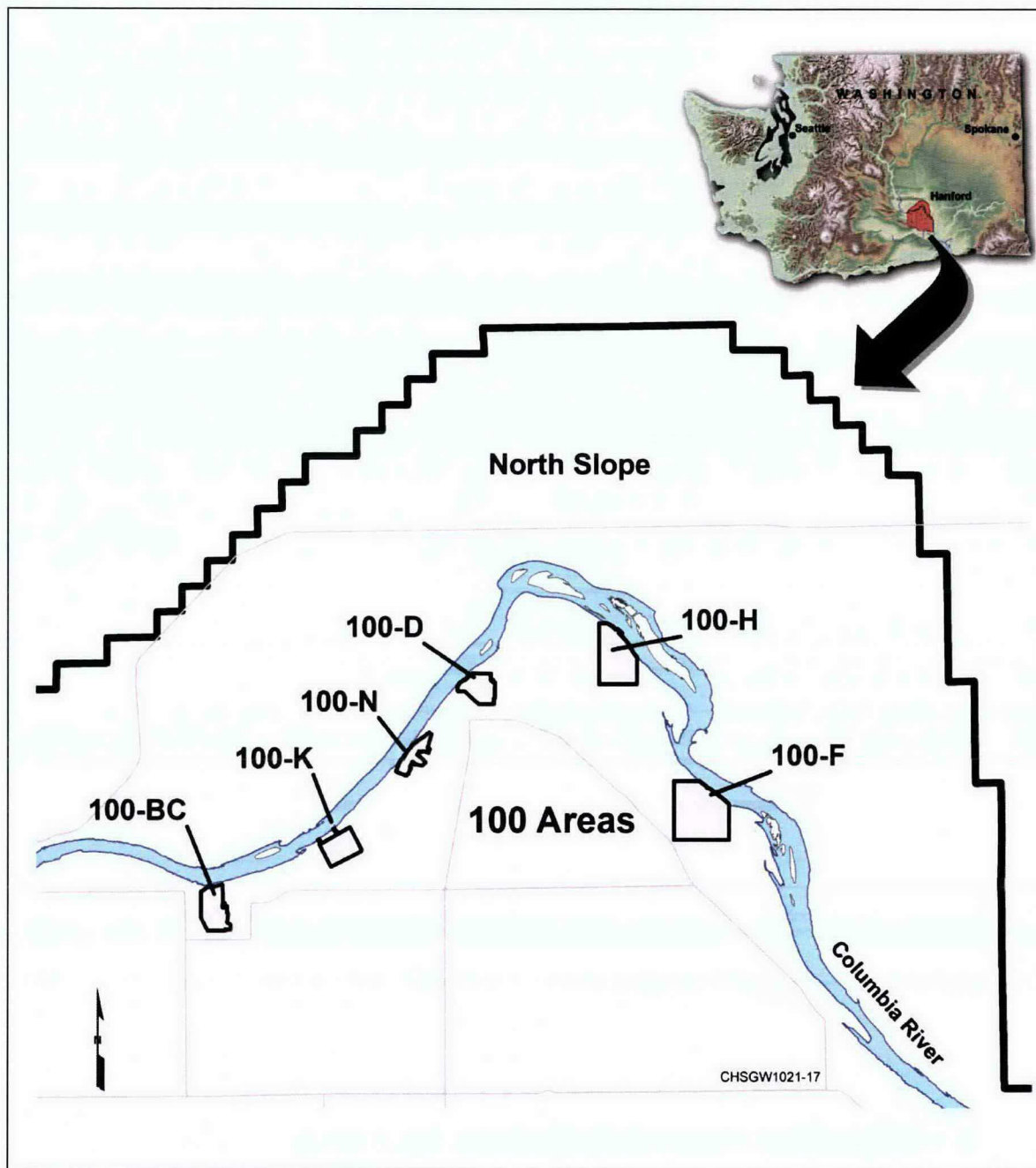


Figure 1-1. Operable Unit Locations Along the Columbia River

## 2 100-HR-3 Operable Unit Remediation

The 100-HR-3 Groundwater OU consists of groundwater underlying the 100-D Area, 100-H Area, and the region between known as the "horn area" (Figure 2-1). In CY 2010, three CERCLA interim action remedies operated in the 100-HR-3 OU: (1) the original 100-HR-3 P&T (HR-3) system in the 100-H Area, which treats groundwater from both the 100-D and 100-H Areas; (2) the DR-5 P&T system in the 100-D Area; and (3) the ISRM barrier in the 100-D Area. The selected remedies are intended to prevent hexavalent chromium from reaching the Columbia River at concentrations exceeding the criteria for protection of freshwater aquatic organisms.

The HR-3 P&T system was specified as an interim action for the 100-HR-3 OU to protect the Columbia River and groundwater (EPA/ROD/R10-96/134). The groundwater extraction system was installed at the D and H Reactor areas in June 1997, with a common treatment facility located in a surplus building near the H Reactor. Currently, water is pumped from the northern portion of the 100-D Area to the 100-H Area for treatment and injection. An additional system was installed in 2004 at the 100-D Area (DR-5 P&T system) to extract and treat high hexavalent chromium concentrations in the central portion of the 100-D Area. The CY 2010 configuration of extraction, injection, and monitoring well locations for the 100-D Area is shown in Figure 2-2, and the 100-H Area well locations are shown in Figure 2-3. Well locations in the horn area are shown in Figure 2-4.

Installation of a PRB for in situ chemical treatment of the hexavalent chromium in the southern plume (100-D Area) began in 2000 as an interim remedial action in accordance with the interim ROD amendment (EPA/AMD/R10-00/122). The ISRM barrier was installed to chemically reduce dissolved hexavalent chromium in groundwater to trivalent chromium, which is a much less soluble and less toxic species. The reduction-oxidation treatment zone is approximately 680 m (2,230 ft) long (aligned parallel to the Columbia River) and is located approximately 100 to 200 m (330 to 660 ft) inland (Figure 2-2). The ISRM barrier is established by injecting sodium dithionite into the aquifer through select wells, which reacts with naturally occurring iron in the soil to create a permeable treatment zone through which contaminated groundwater flows. The progress and performance of the ISRM barrier are provided in Section 2.3.4 and not as a separate document as in previous reporting periods.

### 2.1 Summary of Operable Unit Activities

The two 100-HR-3 OU P&T systems were designed to reduce the amount of hexavalent chromium entering the Columbia River in the 100-D and 100-H Areas. In CY 2010, hexavalent chromium concentrations remained above the 20 µg/L remedial action goal in compliance wells for the P&T system. During CY 2010, the HR-3 and DR-5 extraction systems removed a combined 106 kg of hexavalent chromium from the aquifer. The southern 100-D Area hexavalent chromium plume is also being remediated using a PRB that immobilizes hexavalent chromium in the aquifer; however, data from recent years indicate that hexavalent chromium is breaking through the barrier. At the end of CY 2010, concentrations in barrier wells ranged from below detection limits to 2,960 µg/L at well 199-D4-39; however, this concentration was flagged as suspect and is not included in the plume map because it is out of trend from the expected 700 to 800 µg/L at this location both preceding and following the suspect sample. Most of the elevated concentrations are in the northeastern half of the barrier. Downgradient of the barrier, the 20 µg/L remedial action goal was met at two of the seven compliance wells. The HR-3 and DR-5 system wells are scheduled to be transferred to the new DX/HX P&T system in 2011.

Construction of the DX facility (2,300 L/min [600 gpm]) was completed at the end of CY 2010. Pilot testing of the facility began in December 2010, treating approximately 55.3 million L (14.6 million gal) and removing an additional 18.4 kg of hexavalent chromium for the year. Construction of the HX system

(3,000 L/min [800 gpm]) is progressing, with the treatment building nearly complete. The HX system is scheduled to go online in December 2011.

An RI/FS is being conducted to support the final ROD for the 100-D and 100-H Areas. Characterization activities began in CY 2009, as described in the RI/FS work plan addendum (DOE/RL-2008-46-ADD1) and implemented through the sampling and analysis plan (DOE/RL-2009-40). The RI/FS addresses contaminant sources (e.g., site history), contaminant flow and transport, and exposure assessment, and it also supports risk characterization, remedial action selection, performance monitoring, and site closure. Data gaps have been identified and are currently being addressed through additional data collection and other investigations that will support final remediation decisions. A series of 15 monitoring wells, 10 vadose zone boreholes, and 5 test pits constitute the subsurface characterization activities. The field work is scheduled for completion by April 2011, with the RI/FS report scheduled to be issued later in the year.

The following subsections discuss the major components of the 100-HR-3 OU interim remedies for groundwater:

- Section 2.2 summarizes the conceptual model for groundwater flow and describes the contaminant plumes and concentrations.
- The activities at the OU for the reporting period, including interim action groundwater remediation, are discussed in Section 2.3. A discussion on ISRM operations is provided in Section 2.3.4.
- Additional OU investigations are summarized in Section 2.4.
- The conclusions and recommendations for the 100-HR-3 OU are presented in Sections 2.5 and 2.6, respectively.

## **2.2 Conceptual Site Model**

The following discussion provides a brief summary of the site conceptual model for the 100-HR-3 OU, including the geologic and hydrogeologic setting and the groundwater contaminants. Additional details are provided in DOE/RL-2008-46-ADD1.

### **2.2.1 Geologic/Hydrogeologic Setting**

The 100-D and 100-H Areas are located in the north central portion of the Hanford Site within the 100-HR-3 Groundwater OU (Figure 2-1), which is the operational name for the area that contains the D, DR, and H Reactor buildings and associated support facilities. It is bordered by the Columbia River and is located approximately 45 km (28 mi) north-northwest of Richland, Washington. The 100-D Area reactors operated between 1944 and 1967, and the 100-H Area reactors operated between 1949 and 1965. The 100-D and 100-H Areas are geographically connected by the intervening horn area. On the northern border of the horn area, the Columbia River turns from a northeastern path and flows to the southeast. The primary sources of groundwater contamination in the 100-HR-3 OU are associated with reactor operations.

Groundwater generally enters the 100-HR-3 OU from the south, with most of the flow moving toward the lower elevations of the 100-H Area. A much smaller portion of regional flow moves directly toward the 100-D Area. Underlying the 100-D Area, groundwater generally flows toward the Columbia River; inland from the Columbia River and beneath eastern portions of the 100-D Area, groundwater generally flows northeast. Northeast of the 100-D Area, groundwater flow is parallel to the river, thereby flowing east-northeast across the horn area and toward the 100-H Area. Groundwater below the 100-H Area discharges northeast and east to the Columbia River. Figure 2-5 presents a groundwater contour map of

the area, which was developed using March 2010 data. This map represents the average CY 2010 groundwater flow conditions beneath the 100-HR-3 OU.

In the 100-HR-3 OU, the groundwater system comprises several hydrostratigraphic units (Figure 2-6). From shallowest to deepest, the units are as follows:

- Surface deposits; recent localized surficial deposits and backfill overlying the Hanford formation beneath the 100-D and 100-H Areas
- Vadose (unsaturated) zone; predominantly Hanford formation gravels; 2 to 30 m (6.6 to 98 ft) thick beneath the 100-D and 100-H Areas
- Unconfined aquifer; predominantly Ringold Formation unit E gravels in the 100-D Area, predominantly Hanford formation underlying the horn area and 100-H Area
- Uppermost aquitard, which includes the Ringold Formation upper mud unit (RUM) (clay and silt)
- Confined and semiconfined discontinuous water-bearing lenses and/or aquifers in the Ringold Formation separated by fine-grained deposits (overbank and paleosol)
- Confined aquitards and aquifers in basalt beneath the Ringold Formation

A significant factor affecting regional groundwater flow beneath the 100-D and 100-H Areas is the variability of hydraulic properties within unconfined aquifer units, including variations in hydraulic conductivity and aquifer thickness. Underlying the 100-D Area, groundwater flows through Ringold Formation unit E; east of the 100-D Area, groundwater flows through the Hanford formation. The Hanford formation is generally more permeable than the Ringold Formation. The gravel-dominated matrix of the Hanford formation generally contains greater than 40 percent basalt (sand-size fraction) as compared to Ringold Formation deposits that generally contain less than 25 percent basalt (WHC-SD-EN-TI-132, *Geologic Setting of the 100-HR-3 Operable Unit, Hanford Site, South-Central Washington*). Hanford gravels may display salt-and-pepper and gray coloring, while Ringold gravels are generally more oxidized and reddish-brown to yellow-red in color. Hanford gravels tend to be less consolidated or cemented than Ringold gravels. Thus, the groundwater flow velocity through the Hanford formation tends to be faster than through Ringold Formation unit E.

Groundwater flow in the 100-D and 100-H Areas is significantly influenced by the Columbia River stage. The river stage fluctuates regularly in seasonal and shorter cycles (e.g., daily river stage changes) due to a combination of natural and anthropogenic influences. During the latter portion of the year when river stage is relatively low (e.g., September 2010; see Figure 2-7), natural groundwater flow is toward the river; when river stage is high (e.g., June 2010; see Figure 2-8), groundwater can flow away from the river or flow parallel to the river. The high river stage can rise more than 3 m (9.8 ft) above the low river stage and can fluctuate a meter or more over short periods (i.e., hours to days) based on operations at the upstream Priest Rapids Dam. Changing river stage can influence groundwater elevations over 1 km (0.6 mi) inland from the river in the 100-HR-3 OU. In addition, because the hydraulic head is lower at the 100-H Area, regional flow from the south tends to move across the horn area toward the 100-H Area.

Other significant influences on groundwater flow are leakage from the 182-D reservoir and drawdown or mounding from the groundwater extraction and injection well network. The zone of uncontaminated groundwater near the 182-D facility suggests long-term contaminant mixing and diversion of contaminated groundwater from the mounding caused by the leaks. In response to the reservoir leakage information, a specific issue was included in *The Second CERCLA Five-Year Review Report for the Hanford Site* (DOE/RL-2006-20) for DOE to provide direction to its operating contractor to conduct

changes to the operation of the reservoir to minimize leakage. Those actions were completed and documented in the closeout of the 5-year review issue. These leaks and their impact to groundwater flow have significantly diminished since the reduction of storage volume in the reservoir in 2004, to the point that influences on groundwater flow from reservoir leakage are indistinguishable from those created by nearby P&T activities.

The groundwater in the Ringold Formation unit E, Hanford formation, and first saturated layer in the RUM are oxygenated and typically have a pH between 7.0 and 8.3. However, the ionic composition of the groundwater in all three units is, to different degrees, is dominated by calcium bicarbonate, and calculations indicate that all are approximately saturated with respect to calcite. Additional chemical characteristics of each unit are discussed in Appendix A.

### 2.2.2 100-HR-3 Operable Unit Groundwater Contaminants

The primary sources of contamination in the 100-HR-3 OU were the support systems for the three water-cooled nuclear reactors (D, DR, and H Reactors) and the structures and processes associated with these reactors. These operations generated large quantities of liquid and solid waste contaminated with radionuclides, hazardous chemicals, or both. Most contaminant sources can be characterized as high-volume, low-concentration wastes emplaced under high hydraulic head and as low-volume, high-concentration wastes emplaced under low hydraulic head. Waste released to the environment created secondary sources of contamination beneath ponds, ditches, cribs, burial grounds, and unplanned release (UPR) sites where contaminants may be retained in the subsurface (vadose zone) and released to the aquifer over long periods of time.

The ongoing characterization and remediation of waste sites in the 100-D and 100-H Areas began in 1996 under the authority provided by the interim action RODs and *Resource Conservation and Recovery Act of 1976* (RCRA) closure and monitoring plans. Remediation primarily consists of removing and disposing soil, debris, and waste material, and then backfilling the remediated waste site. A portion of the 100-D and 100-H Area waste sites (i.e., trenches, pits, and burial grounds) have already been remediated and dispositioned. The remediation status of each waste site is described in detail in DOE/RL-2008-46-ADD1.

The RI/FS targeted a number of key waste sites for additional characterization to better define the nature and extent of contaminants and potential remaining sources. Sites planned for investigation include the following: 100-D-12 french drain associated with the sodium dichromate/acid railcar and truck unload station (where highly concentrated sodium dichromate solutions may have been drained during railcar unloading operations), 116-D-1A Trench, 116-D-1B Trench, 116-D-7 retention basin, 116-DR-1&2 Trench, 116-DR-9 retention basin, 116-H-1 Trench, 116-H-4 pluto crib, 183-H solar evaporation basins, 116-H-7 retention basin, 116-D-6:3 reactor fuel storage basin, and 116-H-6:3 reactor fuel storage basin.

The principal COC in the 100-HR-3 OU is hexavalent chromium. The remedial action goal is to reduce the hexavalent chromium concentration in groundwater to less than 10 µg/L by the time it reaches the Columbia River. Strontium-90, tritium, technetium-99, and nitrate are co-contaminants that are actively monitored (DOE/RL-93-43, *Limited Field Investigation Report for the 100-HR-3 Operable Unit*). In addition, sulfate is a contaminant of interest because the secondary drinking water standard (DWS) has been exceeded in the past in a limited number of wells since installation of the ISRM barrier. Institutional controls are implemented to satisfy RAO #2, which limits human exposure to hexavalent chromium and co-contaminants.

The *Interim Action Monitoring Plan for the 100-HR-3 and 100-KR-4 Operable Units* (DOE/RL-96-90) and "Sampling Changes to the 100-HR-3 and 100-KR-4 Operable Units" (Wanek, 1998) define the

sampling protocols implemented for CY 2010. The contaminant monitoring results are presented in the following subsections. Summaries the maximum 2009 and 2010 contaminant and co-contaminant concentrations detected in the 100-D and 100-H Area wells or aquifer tubes are provided in Tables 2-1 and 2-2. The CY 2010 data set is reduced in for the fall of 2010 due to a stop work that was issued to resolve safety issues with sampling of some wells. Therefore, the number of points in the interpretation was less than normal; however, this did not impact the operation of the remedies, and future sampling will document the impact of the remedy at locations that were not sampled in 2010.

### **2.2.2.1 Hexavalent Chromium**

The remedial action goal for hexavalent chromium for 100-HR-3 OU groundwater interim actions is 20 µg/L in a near-shore compliance well for both the P&T systems and the ISRM barrier system. These systems are given an allowance for a 1:1 attenuation factor to meet the 10 µg/L ambient water quality criterion in the hyporheic zone, as determined by the following:

- EPA/AMD/R10-00/122, *Declaration of the Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units, Benton County, Richland, Washington*
- EPA/ROD/R10-99/039, *Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington*
- *Explanation of Significant Differences for the 100-HR-3 and 100-KR-4 Operable Units Interim Action Record of Decision: Hanford Site Benton County, Washington* (EPA et al., 2009).

Hexavalent chromium concentrations are monitored in extraction wells, compliance wells, monitoring wells, and aquifer tubes in the 100-D and 100- Area P&T operational areas (Figures 2-2 and 2-3). Figures 2-9 and 2-10 show the distribution of hexavalent chromium in 100-HR-3 OU groundwater during spring and fall 2010. Note that the fall 2010 map contains only a partial data set due to the stop work that occurred at that time. The iso-concentration contours were drawn based on 2010 data, where available. In areas where data are sparse, historical iso-concentration contours were used to aid in completing the map.

### **Southern 100-D Area Plume**

Underlying the 100-D Area, hexavalent chromium in the unconfined aquifer occurs in two distinct plumes often referred to as the southern and northern plumes. Historical handling activities of 70 percent sodium dichromate solution at the 100-D Area (100-D-12 and former railcar unloading station) are the likely source of the southern plume. The southern plume lies south and west of the 183-DR filter plant. In CY 2010, the plume configuration did not change compared to CY 2009. In addition, despite removing more than 326 kg of hexavalent chromium through P&T operations, the groundwater plume size and average concentrations beneath the 100-D Area have not markedly decreased over the past decade. The new DX facility, with a treatment capacity of 2,300 L/min (600 gpm), will help facilitate hexavalent chromium removal from 100-D Area groundwater.

Among the wells in the southern hexavalent chromium plume, the highest hexavalent chromium concentrations in groundwater samples were found in wells 199-D5-99 and 199-D5-122, with concentrations as high as 11,900 µg/L (February 2010) and 69,700 µg/L (August 2010). For well 199-D5-99, hexavalent chromium concentrations are considerably lower than measured in CY 2009 (49,300 µg/L); however, hexavalent chromium concentrations in groundwater samples from well 199-D5-122 have increased from CY 2009 to 59,600 µg/L. The 100-D Area hexavalent chromium plume for spring 2010 is shown in Figure 2-11. The figure also shows hexavalent chromium

concentration plots for selected wells within the plume. Maximum hexavalent chromium levels generally coincide with low river conditions and occur in the late fall to early spring.

Wells that monitor the aquifer in the central 100-D Area (199-D5-33, 199-D5-36, and 199-D5-44) continue to have low hexavalent chromium concentrations. These wells are located between the southern and northern hexavalent chromium plumes. In CY 2010, hexavalent chromium was not detected in groundwater samples from these wells, which may be the result of infiltration of clean water from the 182-D reservoir, leaking raw water pipes, or injection of treated water into wells 199-D5-41 and 199-D5-42. Repairs and operational changes have reduced the amount of infiltration from the 182-D reservoir; however, hexavalent chromium concentrations have not fully rebounded in the aquifer beneath this area.

In 100-D Area aquifer tubes, hexavalent chromium concentrations in 2010 were at the lower end of the historical range (Figure 2-12). The highest hexavalent chromium concentration detected in aquifer tubes in the 100-D Area was in Redox-1-3.3 (294 µg/L), downgradient of the ISRM barrier. Hexavalent chromium concentrations downgradient of the ISRM barrier have decreased since the late 1990s but continued to remain above the cleanup standard in CY 2010.

A cluster of four new aquifer tubes (C7645, C7646, C7647, and C7648) were installed upstream of the ISRM barrier in April 2010 as part of the RI/FS to define the extent of the hexavalent chromium and strontium-90 southeast of the 100-D Area. Groundwater samples collected from these new tubes during the last half of the CY 2010 had hexavalent chromium concentrations ranging from nondetect to 8.9 µg/L.

### **Northern 100-D Area Plume**

The northern hexavalent chromium plume extends north from the D Reactor to the Columbia River. Operationally, the northern plume is located downgradient of the former sodium dichromate distribution system, which contained less concentrated solutions than the initial 70 percent solution brought in by railcar at 100-D-12. In CY 2010, the northern hexavalent chromium plume had not changed significantly compared to CY 2009. Among the wells in the northern hexavalent chromium plume, the highest hexavalent chromium concentrations in groundwater were found in wells 199-D5-125 and 199-D5-126, with concentrations as high as 2,310 µg/L and 2,150 µg/L, respectively. This is largely unchanged from the CY 2009 concentrations of 2,350 µg/L (199-D5-125) and 1,970 µg/L (199-D5-126). These wells were added in the first quarter of fiscal year (FY) 2009 and are located directly in the center of the plume. Figure 2-13 shows hexavalent chromium concentrations within the north plume, as well as the hexavalent chromium concentration plots for selected wells within the plume.

Well 199-D5-15 monitors groundwater near a potential source of the northern hexavalent chromium contamination. Hexavalent chromium concentrations were low from 1999 through 2003 due to mixing with nearby leaking water lines, which were repaired in 2004 (PNNL-15070, *Hanford Site Groundwater Monitoring for Fiscal Year 2004*). Concentrations began to increase in 2004, reaching a maximum of 2,450 µg/L in May 2007. Hexavalent chromium in this well subsequently declined to approximately 1,000 µg/L in 2008 and remained below 700 µg/L during CY 2010, with a maximum concentration of 659 µg/L. Hexavalent chromium concentrations in wells 199-D5-14 and 199-D5-16 (downgradient of well 199-D5-15) also increased in 2008 but steadily decreased during the reporting period. Vadose zone soil sampling conducted during the 100-D Area chromium source investigations (DOE/RL-2009-92, *Report on Investigation of Hexavalent Chromium in the Southwest 100-D Area*; DOE/RL-2010-40, *Report on Investigation of Hexavalent Chromium Source in the Northern 100-D Area*) discovered small amounts of hexavalent chromium in the vadose zone in a few locations but did not identify a large source capable of producing the high concentrations in some groundwater monitoring wells. Another theory for

the northern plume is that it was split off from the south plume hydraulically via leakage from the 182-D reservoir and associated piping.

Hexavalent chromium concentrations in aquifer tubes downgradient of the northern plume have declined since the late 1990s. Only two of the five aquifer tube clusters used to monitor the northern plume were sampled in CY 2010. The only aquifer tube with a groundwater sample above the remedial action goal was tube 36-M at 22.1 µg/L.

### **Horn Area Plume**

The hexavalent chromium plume underlying the horn area is believed to have originated in the 100-D Area and has subsequently migrated toward the 100-H Area. A significant portion of the mass in the horn area may have resulted from routing of cooling water to the 116-DR-1&2 Trench during the final months of operation during 1967 at 105-D.

During CY 2010, groundwater sampling results showed the presence of hexavalent chromium in groundwater beneath the horn area; however, the plume did not change significantly compared to CY 2009. Higher hexavalent chromium concentrations are restricted to the area immediately adjacent to the 100-D Area. Injection wells in the 100-H Area create a hydrologic barrier on the northeastern side of the plume, preventing the plume from extending eastward into the northern portion of 100-H Area (Figure 2-9).

The central core of the horn area plume had concentrations between 50 and 90 µg/L in wells 699-98-46, 699-97-45, 699-97-43B, and 699-95-45. Thus, hexavalent chromium concentrations in these wells were largely unchanged between CY 2009 and CY 2010.

Three wells in the horn area monitor the RUM: 699-97-43C, 699-97-45B, and 699-97-48C. Of these wells, 699-97-43C and 699-97-45B were sampled during CY 2010 with no detections of hexavalent chromium. Well 699-97-48C reported a high hexavalent chromium concentration of 42.3 µg/L in December 2010; which is slightly higher than the previous year's concentration of 38.7 µg/L.

### **100-H Area Plume**

The size of the hexavalent chromium plume in the unconfined aquifer underlying the 100-H Area has been significantly reduced since startup of P&T operations in 1997. However, in CY 2010, the plume did not change significantly compared to CY 2009. A relatively smaller and lower concentration hexavalent chromium plume remains adjacent to the Columbia River. The new HX P&T system will help facilitate remediation by expanding capture and treating additional contaminated groundwater.

During CY 2010, groundwater in the 100-H Area predominantly contained less than 20 µg/L hexavalent chromium; however, several wells upgradient of the 100-H Area continued to have hexavalent chromium concentrations above the remedial action goal. The highest hexavalent chromium concentration for CY 2010 was 91.8 µg/L in well 199-H1-43. This well is downgradient from well 699-97-43B, which has had the highest hexavalent chromium concentration since 2007. In CY 2010, well 699-97-43B had a maximum concentration of 85.2 µg/L, which is a decrease from the previous reporting period (sampled in November 2008 at 91.5 µg/L). Figure 2-14 shows hexavalent chromium concentrations in groundwater underlying the 100-H Area and selected trend plots. An increase in hexavalent chromium concentrations was noted in the southern portion of the area near well 199-H3-5, which is one of the original injection wells at the HR-3 system. Since shutdown of these wells, some encroachment of the horn area plume has occurred in the vicinity. Well 199-H3-5 will be added to the HX P&T system.

Monitoring wells 199-H3-2C and 199-H4-12C and piezometer 199-H4-15CS are screened within the first water-bearing layer within the RUM. In CY 2010, groundwater samples collected from these

wells/piezometer continued to show elevated hexavalent chromium concentrations. In CY 2009, these wells/piezometer were used for a series of aquifer tests to gather data on the presence of deep chromium in the RUM. The following discussion provides observations that were noted for CY 2010.

Well 199-H3-2C (screened in the first water-bearing layer in the RUM) is located on the western side of the 100-H Area, upgradient of the 100-H Area waste sites. Hexavalent chromium concentrations in groundwater samples from this well have increased over the last several years, to approximately 50 µg/L in FY 2007 and 2008. During the 2009 aquifer test, the highest value observed was 112 µg/L. The highest hexavalent chromium concentration detected in CY 2010 was 41 µg/L. Adjacent well 199-H3-2A, completed in the unconfined aquifer, had much lower hexavalent chromium concentrations (less than 16 µg/L).

Well 199-H4-12C (screened in the first water-bearing layer in the RUM) is located near the Columbia River, downgradient of the 183-H solar evaporation basins and adjacent to extraction well 199-H4-12A (screened in the unconfined aquifer). Well 199-H4-12C had declining hexavalent chromium concentrations during FY 2008, decreasing to approximately 80 µg/L. During CY 2009, hexavalent chromium concentrations were between 80 and 100 µg/L until early November 2009, when concentrations increased to a maximum of 121 µg/L as a result of aquifer testing. The highest hexavalent chromium concentration detected in CY 2010 was 140 µg/L.

Piezometer 199-H4-15CS is adjacent to an extraction well. Hexavalent chromium concentrations in this piezometer were steady at levels near 100 µg/L until November 2009, when the concentration increased to 115 µg/L as a result of aquifer testing. The highest hexavalent chromium concentration detected in CY 2010 was 129 µg/L; however, concentrations in shallower wells 199-H4-15A and 199-H4-15B were much lower, at 31 and 28 µg/L, respectively.

Hexavalent chromium concentrations in aquifer tubes in the main 100-H Area were below 20 µg/L, with the exception of tube C7650. Aquifer tube C7650 was installed as part of the RI/FS, downgradient of the 116-H-7 waste site in April 2010, to define the extent of hexavalent chromium and strontium-90 contamination. Groundwater samples collected from this new aquifer tube during the last half of the year showed hexavalent chromium concentrations ranging from 6.6 to 30.8 µg/L.

Concentrations greater than 20 µg/L were also observed along the horn area, reflecting the plume as it intercepts the Columbia River. The highest concentration upstream of the 100-H Area was 42.2 µg/L in aquifer tube C5641.

### **2.2.2.2 Strontium-90**

The source of strontium-90 is likely the fuel storage basins on the back sides of the reactor as a result of fuel cladding failures that allowed fission products to mix with the fuel storage basin water.

#### **100-D Area**

In the 100-D Area, only one groundwater sample collected in CY 2010 had a strontium-90 concentration exceeding the DWS of 8 pCi/L (RI/FS borehole characterization sample from well 199-D3-5 at 8.5 pCi/L). Groundwater samples collected from this well the previous day had a maximum detection of only 4.5 pCi/L.

The areas near the former retention basins in the north and near the D Reactor in the central 100-D Area have historically had strontium-90 detections in groundwater. Well 199-D8-68, near the former retention basins, has had concentrations ranging from 2 to 14 pCi/L since 1998; concentrations were 3 pCi/L in CY 2010, showing a decreasing trend. During CY 2010, none of the 100-D Area aquifer tubes were sampled for strontium-90.

**100-H Area**

The distribution of strontium-90 in groundwater underlying the 100-H Area has not significantly changed in recent years. Strontium-90 concentrations in groundwater continued to exceed the 8 pCi/L DWS in several wells located on the southeast side of the area. The highest concentration of strontium-90 detected in groundwater was 28 pCi/L in well 199-H4-13, located downgradient of the 116-H-7 retention basin. During CY 2010, none of the 100-H Area aquifer tubes were sampled for strontium-90.

**2.2.2.3 Technetium-99 and Uranium**

The source of technetium-99 and uranium is likely the fuel storage basins on the back side of the reactors as a result of fuel cladding failures that allowed fission products to mix with the fuel storage basin water.

**100-D Area**

In CY 2010, technetium-99 and uranium concentrations in groundwater underlying the 100-D Area were less than the respective DWSs of 900 pCi/L and 30 µg/L, respectively. The highest detected technetium-99 concentration was 160 pCi/L in an RI/FS borehole characterization sample from well 199-D3-5, which is far below the DWS. However, this potential concentration is noteworthy because it is located in an area where technetium-99 has not been observed previously; therefore, confirmatory monitoring will continue at this location. The highest concentration of uranium in groundwater was 5.82 µg/L in well 199-D6-3 (RI/FS borehole characterization sample); this value is much lower than both the Hanford Site background for uranium (9.85 µg/L) and the DWS of 30 µg/L. During CY 2010, none of the 100-D Area aquifer tubes were sampled for technetium-99 or uranium.

**100-H Area**

In CY 2010, technetium-99 and uranium concentrations in groundwater underlying the 100-H Area were less than their respective DWSs. Although a groundwater sample from well 199-H6-4 had 68 pCi/L detection of technetium-99, this radionuclide has not been historically detected in this area. In addition, samples obtained from surrounding wells were below the laboratory detection limit. This well will be sampled in the future to determine the validity of this result.

In CY 2010, uranium was positively detected in all analyzed 100-H Area groundwater samples. The maximum concentration was identified in a groundwater sample collected from well 199-H4-3 (12.2 µg/L). This is a decrease from CY 2009; however, this value is below both the Hanford Site background for uranium and the DWS.

During CY 2010, none of the 100-H Area aquifer tubes were sampled for technetium-99 or uranium. However, during CY 2009, aquifer tubes AT-H-1-D, AT-H-2-D, and AT-H-3-D were sampled for technetium-99 and uranium in the 100-H Area, and technetium-99 was not positively detected in any of the samples. Uranium was detected at low levels in all three aquifer tubes, with the maximum of 1.67 µg/L in tube AT-H-3-D.

**2.2.2.4 Tritium**

The source of tritium is likely the fuel storage basins on the back side of the reactors as a result of fuel cladding failures that allowed fission products to mix with the fuel storage basin water.

**100-D Area**

In CY 2010, tritium concentrations in groundwater underlying the 100-D Area were less than the DWS of 20,000 pCi/L. A groundwater sample collected from well 199-D6-3 (RI/FS borehole characterization sample) had a tritium concentration of 20,000 pCi/L, which is at the DWS. In addition, low tritium concentrations were detected in several aquifer tubes in the southern portion of the

100-D Area shoreline. In general, tritium concentrations in groundwater underlying the 100-D Area are declining.

#### **100-H Area**

In CY 2010, tritium concentrations in groundwater underlying the 100-H Area were generally less than 5,000 pCi/L, which is well below the DWS. In addition, groundwater samples collected from wells in the horn area had tritium concentrations between 2,000 and 4,500 pCi/L. Since the horn area is upgradient of the 100-H Area, tritium concentrations are not expected to increase above the DWS in future sampling events. In general, tritium concentrations in groundwater underlying the 100-H Area and horn area are declining.

#### **2.2.2.5 Nitrate and Nitrite**

The source of nitrate and nitrite is likely the result of use and disposal of nitric acid that was used for a variety of cleaning and decontamination operations in the reactor areas.

#### **100-D Area**

During CY 2010, nitrate concentrations in groundwater underlying the northern 100-D Area increased compared to CY 2009. The plume has two lobes, with nitrate concentrations continuing to exceed the DWS (45 mg/L) in both lobes. A groundwater sample collected from well 199-D5-15 had the maximum detected nitrate concentration at 99.2 mg/L. The RI/FS wells 199-D5-133 and 199-D6-3, drilled during CY 2010, also showed elevated nitrate with maximum concentrations of 81 and 77.9 mg/L, respectively (RI/FS borehole characterization samples). Figure 2-15 shows the distribution of nitrate in groundwater underlying the 100-D Area.

The southern portion of the nitrate plume is intercepted by the ISRM barrier, which chemically reduces the nitrate. During CY 2009, a maximum nitrate concentration of 95 mg/L was detected in groundwater from well 199-D2-6 in the southern 100-D Area. However, in CY 2010, the nitrate concentration in groundwater from this well decreased to 69.5 mg/L. Nitrate concentrations in 100-D Area aquifer tubes were all less than 45 mg/L.

In CY 2010, nitrite was detected in groundwater samples collected from several wells near the ISRM barrier; however, the measured concentrations were less than the DWS of 3.3 mg/L.

#### **100-H Area**

During CY 2010, nitrate concentrations in groundwater underlying the 100-H Area were below the DWS of 45 mg/L. The highest concentration (44.3 mg/L) was observed in an RI/FS borehole characterization sample collected from well 199-H6-3 in the southern 100-H Area. This well is located upgradient of aquifer tube 51, which has historically had elevated nitrate concentrations. Aquifer tube 51 was not sampled for nitrate in CY 2010, but the highest value in CY 2009 was 46 mg/L. Aquifer tubes in the southern 100-H Area and further downstream have had nitrate levels near or above the 45 mg/L DWS in recent years; however, these sites were not sampled in CY 2010.

#### **2.2.2.6 Sulfate**

The source of sulfate includes sulfuric acid that was used in a variety of cleaning and decontamination activities in the reactor areas, as well as the use of sodium dithionite in the treatment of the ISRM barrier in the 100-D Area.

#### **100-D Area**

During CY 2010, sulfate concentrations in groundwater underlying much of the southern 100-D Area remained greater than 100 mg/L. Excluding wells influenced by the ISRM barrier, concentrations were below the secondary DWS (250 mg/L), with a maximum concentration of 202 mg/L in well 199-D6-3

(RI/FS borehole characterization sample). Sulfate concentrations in samples from 100-D Area aquifer tubes are generally low, except downgradient of the ISRM barrier. Previous sodium dithionite solution injections at the barrier increased sulfate concentrations to levels above the secondary DWS in the ISRM barrier and in some downgradient wells and aquifer tubes. Elevated sulfate might have been expected sooner in aquifer tubes in this area; water-level increases in the aquifer due to rises in river stage may sufficiently reduce or reverse the local gradient, resulting in extended travel times. The highest concentration in CY 2010 was 776 mg/L in aquifer tube DD-43-3, which is the highest sulfate concentration ever detected in an aquifer tube. Aquifer tube DD-42-4 had results above the 250 mg/L secondary DWS in CY 2009 and a maximum concentration of 616 mg/L in CY 2010.

#### **100-H Area**

In CY 2010, sulfate concentrations in groundwater underlying the 100-H Area were below the secondary DWS (250 mg/L). The maximum concentration detected was 83.6 mg/L in a sample collected from well 199-H4-46.

#### **2.2.2.7 Gross Beta**

##### **100-D Area**

Historical groundwater samples collected from wells in the ISRM barrier have contained detectable amounts of gross beta, which was primarily caused by naturally present potassium-40 in the pH buffer used during injection (PNNL-13116, *Hanford Site Groundwater Monitoring for Fiscal Year 1999*). During CY 2010, three wells in the ISRM barrier were sampled for gross beta analysis. The three groundwater sample results were all below the DWS of 50 pCi/L, with a maximum concentration of 19 pCi/L in well 199-D4-84. Well 199-D4-19 was not sampled in CY 2010 but had a maximum gross beta value of 140 pCi/L in November 2009.

##### **100-H Area**

Strontium 90 is present in groundwater underlying the 100-H Area, which causes gross beta concentrations in groundwater to exceed the 50 pCi/L DWS. In CY 2010, a groundwater sample collected from well 199-H4-13 had the highest gross beta concentration detected (69 pCi/L).

### **2.3 CERCLA Operable Unit Activities**

This section summarizes the non-RI/FS CERCLA activities for the 100-HR-3 OU during the reporting period, including groundwater remedial actions.

An interim remedial action ROD for the 100-HR-3 Groundwater OU was issued in April 1996 (EPA/ROD/R10-96/134) pursuant to the Hanford Site's 1989 listing on the National Priorities List for CERCLA. The goal of the resulting interim remedial action is to prevent discharge of hexavalent chromium to the Columbia River. The *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Units' Interim Action* (DOE/RL-96-84) implemented the P&T interim remedial actions in accordance with the interim ROD.

The interim action goal was changed from 22 µg/L to 20 µg/L in August 2009 by the explanation of significant differences for the 100-HR-3 and 100-KR-4 OUs (EPA et al., 2009). The explanation of significant differences sets a 20 µg/L threshold at onshore, near-river monitoring locations to achieve the ambient water quality criterion of 10 µg/L. As indicated in the ROD, an attenuation factor of 1:1 is expected before the groundwater would reach the aquatic receptor point of concern within the river substrate, ensuring that the ambient water quality criterion of 10 µg/L in the river substrate will be met.

The second CERCLA 5-year review (DOE/RL-2006-20) was published in November 2006. The review identified four actions pertaining to the 100-HR-3 OU interim action groundwater remediation:

- **Action 9-2:** *Incorporate the horn area into the 100-HR-3 OU interim ROD (EPA/ROD/R10-99/039); Action 9-1 indicates that the horn area contains a plume requiring immediate remediation (September 2009).*

The DOE has completed the RPO evaluation of the P&T system and is currently implementing the results (SGW-40044, *100-HR-3 Remedial Process Optimization Modeling Technical Memorandum*). The DOE installed additional extraction and injection wells throughout the horn area in FY 2009 and FY 2010 as part of RPO, which resulted in the 2,300 L/min (600 gpm) DX system and the 3,000 L/min (800 gpm) HX system.

- **Action 11-1:** *Initiate limited iron amendments to evaluate whether this enhances ISRM barrier performance (September 2007).*

This action was previously completed. Results of the iron amendment tests are documented in the *Treatability Test Report on Mending the In Situ Redox Manipulation Barrier Using Nano-Size Zero-Valent Iron* (DOE/RL-2009-35).

- **Action 11-2:** *Expand groundwater P&T extraction within the 100-D Area by 378.5 L/min (100 gpm) to enhance remediation of the hexavalent chromium plume (no due date).*

The DOE installed additional extraction and injection wells in FY 2009 as part of the RPO (SGW-38338; SGW-40044). The DX system became operational on December 16, 2010.

- **Action 12-1:** *Perform additional characterization of the 100-H Area aquifer below the initial aquitard (September 2009).*

The DOE installed three wells in the horn area screened in the RUM (DOE/RL-2008-42, *Hydrogeological Summary Report for the 600 Area Between 100-D and 100-H for the 100-HR-3 Groundwater Operable Unit*) and continued to monitor three wells in the 100-H Area.

Section 2.4.1 presents the summary of the aquifer tests that were performed in CY 2009 to gather data to provide additional information on the deep hexavalent chromium contamination in the 100-H Area (SGW-47776, *Aquifer Testing, and Rebound Study in Support of the 100-H Deep Chromium Investigation*). Future work will be incorporated into the systematic planning process for the 100-HR-3 OU.

Five wells (three in the 100-H Area and two in the 100-D Area) were installed as part of the RI/FS work plan. The wells will be drilled through the RUM and screened within the first water-bearing layer encountered (DOE/RL-2008-46-ADD1).

### 2.3.1 HR-3 Pump-and-Treat System

The HR-3 P&T system extracts groundwater through wells in the northern plume (100-D Area) and in the 100-H Area plume. The extracted groundwater is transferred through an aboveground pipeline to a treatment building in the 100-H Area. Hexavalent chromium is removed from the extracted groundwater using IX resins. Treated water is then discharged to injection wells, which are screened in the unconfined aquifer underlying the 100-H Area. The system has used up to 12 extraction wells (10 wells in the unconfined aquifer and 2 wells in the RUM). The configuration of the extraction network has varied at times depending on need (i.e., not all extraction wells are operated simultaneously). The HR-3 P&T system also includes three injection wells in the 100-H Area. The existing treatment capacity for the HR-3 P&T system is 1,100 L/min (300 gpm).

### **2.3.1.1 Changes in 2010**

The size of the hexavalent chromium plume in the unconfined aquifer underlying the 100-H Area has been significantly reduced since startup of P&T operations in 1997. However, in CY 2010, this plume did not change significantly compared to CY 2009. A relatively smaller and lower concentration hexavalent chromium plume remains adjacent to the Columbia River. The new HX P&T system will help facilitate remediation by expanding capture and treating additional contaminated groundwater.

The extraction/injection well network has been modified several times to accommodate the hexavalent chromium plume as it changes over time. In CY 2010, wells 199-H3-2C and 199-H4-12C (RUM wells) were added to the HR-3 P&T system. These wells previously monitored a water-bearing layer within the RUM, which showed elevated hexavalent chromium concentrations.

Table 2-3 identifies the current extraction, compliance, and injection wells for the HR-3 P&T system in CY 2010. This table does not suggest that the extraction and injection wells were operating at the same time; therefore, the total extraction and injection rates may not match.

### **2.3.1.2 Treatment System Performance**

The total dissolved mass of hexavalent chromium remaining in the unconfined aquifer underlying the 100-HR-3 OU was estimated using the fall 2009 iso-concentration map. The areal extent of the average hexavalent chromium concentrations within each contour interval was multiplied by an assumed average porosity value of 15 percent by an average aquifer thickness of approximately 7.5 m (24.6 ft). The results indicate that approximately 1,125 kg of hexavalent chromium remained in the aquifer. These results will help provide perspective on P&T system performance in the 100-HR-3 OU.

During CY 2010, the HR-3 P&T system extracted 267.9 million L (70.8 million gal) of groundwater from the 100-HR-3 OU. This is a 51 percent increase in volume when compared to 177.3 million L (46.84 million gal) processed in CY 2009. The system removed 31 kg of hexavalent chromium during CY 2010, bringing the total amount removed to 392.9 kg since 1997, in addition to the 30 kg removed by a pilot-scale system in the early 1990s. The amount of hexavalent chromium removed in CY 2010 was an increase of 95 percent in mass removed when compared to 15.9 kg processed in CY 2009. The average removal efficiency for CY 2009 was 96 percent, which is slightly higher than the 95 percent reported in CY 2010. A summary of operational parameters and total system performance for the HR-3 P&T system (100-D and 100-H Areas) in CY 2010 is in Table 2-4.

Figure 2-16 shows the influent and effluent concentrations for the treatment systems. The average influent hexavalent chromium concentration in CY 2010 was 122 µg/L. The average effluent concentration for the reporting period was 4.9 µg/L.

Individual wells were shut off intermittently for periods of days to weeks, and the entire system was shut down for a 3-week period from mid-July to early August; otherwise, total system pumping rates remained relatively constant during CY 2010. Figure 2-17 shows the system availability for the reporting period. There was unplanned downtime of 1 hour in May for an electrical power loss, 2.8 hours in September for an air conditioning problem, and 9.6 hours in November for an electrical power loss.

### **2.3.1.3 Compliance Monitoring**

The monitoring requirements for the HR-3 P&T system are specified in the interim monitoring plan (DOE/RL-96-90). Long-term monitoring requirements for the 100-H Area are derived from Tri-Party Agreement Change Control Form 107.

Wells 199-D8-54A and 199-D8-71 are the two specified compliance points for the HR-3 P&T system in the 100-D Area. Well 199-D8-54A was sampled 11 times during the reporting period because it was an

extraction well, with concentrations ranging from 25 to 109 µg/L. Well 199-D8-71 was sampled twice during the reporting period (March and May 2010). The highest hexavalent chromium concentration detected in groundwater from this well was 130 µg/L (slightly lower than CY 2009), with a maximum detected concentration of 136 µg/L. Hexavalent chromium concentrations in these compliance wells exceeded the 20 µg/L remedial action goal during CY 2010, which is unchanged from the previous reporting period.

In CY 2010, a small area of hexavalent chromium exceeded 50 µg/L across the eastern boundary of the 100-D Area. The zone appeared to have a north-south axis, with wells 199-D8-69 and 199-D8-70 (compliance wells) located in the portion of the zone having hexavalent chromium concentrations between 50 and 100 µg/L in CY 2010. The compliance wells continued to show variable hexavalent chromium concentrations, with the lowest concentrations in the early summer when the river stage was high (Figure 2-13). Most concentrations in these compliance wells exceeded the 20 µg/L remedial action goal during CY 2010, which is unchanged from the previous reporting period. The highest detected concentrations were 64.5 and 82.7 µg/L in wells 199-D8-69 and 199-D8-70, respectively.

In the 100-H Area, one compliance well (199-H4-5) was scheduled for monthly sampling to evaluate HR-3 P&T system performance; however, this well could only be sampled for 8 of the 12 months due to the stop work safety issues previously discussed. None of the samples exceeded the 20 µg/L remedial action goal, and the maximum hexavalent chromium concentration detection was 10 µg/L.

Four additional wells in the 100-H Area are designated as dual-purpose wells. Well 199-H4-3 is designated as an extraction/performance well, and wells 199-H4-4, 199-H4-63, and 199-H4-64 are designated as extraction/compliance wells. All four wells had at least one sample above the remedial action goal of 20 µg/L during CY 2010. Well 199-H4-64 had the highest concentration of 26 µg/L, which is a decrease from 61 µg/L in CY 2009.

## **2.3.2 DR-5 Pump-and-Treat System**

A second P&T system, DR-5, began operating at the end of July 2004 to treat increasing hexavalent chromium concentrations in 100-D Area wells southwest of the original P&T system. The DR-5 P&T system extracts, treats, and injects groundwater in the 100-D Area and has a treatment capacity of 190 L/min (50 gpm). Groundwater is extracted from four wells and treated in the 100-D Area at the DR-5 treatment facility using a metal anion-exchange system with onsite regeneration. Treated groundwater is then injected into wells 199-D5-41 and 199-D5-42. The system has been modified (e.g., pumping rate changes, and extraction wells added or subtracted) several times over the years to increase the rate of remediation and widen the capture zone. During CY 2010, four extraction wells and two injection wells were operating on different schedules.

### **2.3.2.1 Changes in 2010**

During CY 2010, the DR-5 P&T system operated with various configurations. In February 2010, extraction well 199-D5-104 and injection well 199-D5-41 were added to the DR-5 P&T system to aid in addressing the 100-D Area south plume. Injection well 199-D5-42 was offline in February for rehabilitation and was back online in September 2010.

The DR-5 P&T system currently consists of four extraction wells: two wells (199-D5-20 and 199-D5-92) are located in the northern hexavalent chromium plume (100-D Area), and two wells (199-D5-39 and 199-D5-104) are located in the southern hexavalent chromium plume (100-D Area). The DR-5 P&T system also includes two injection wells (199-D5-41 and 199-D5-42) in the 100-D Area. Table 2-5 identifies the current extraction and injection wells. Some of the upgrades currently in progress for the treatment system will add water treatment capability in the 100-D Area.

For CY 2010, the areal extent of the southern hexavalent chromium plume in the 100-D Area did not change significantly compared to CY 2009. In addition, despite removing over 326 kg of hexavalent chromium through P&T operations, average concentrations beneath the 100-D Area have increased dramatically since the hot spot was identified 3 years ago. The new DX facility, with a treatment capacity of 2,300 L/min (600 gpm), will help facilitate remediation by expanding the capture zone, thereby drawing a larger volume of contaminated groundwater for treatment. In addition, drilling and installation of new characterization and monitoring wells has aided in better definition of the extent of contamination.

### **2.3.2.2 Treatment System Performance**

During CY 2010, the DR-5 P&T system extracted 44.6 million L (11.8 million gal) of groundwater from the 100-D Area, which is an 8 percent decrease compared to 48.6 million L (12.8 million gal) processed in CY 2009. The system removed 74.9 kg of hexavalent chromium during the reporting period, for a total of 326.2 kg removed since 2004. The amount of hexavalent chromium removed in CY 2010 was an increase of 70 percent in mass removed when compared to 44.2 kg processed in CY 2009. The average removal efficiency for CY 2010 was 99.8 percent, which is essentially the same as the 99.9 percent reported in CY 2009. A summary of operational parameters and total system performance for the DR-5 P&T system is presented in Table 2-6.

The average influent hexavalent chromium concentration in CY 2010 was 1,750  $\mu\text{g/L}$ . The average effluent concentration for the reporting period was 7  $\mu\text{g/L}$ . Figure 2-18 shows the influent and effluent concentrations for the treatment systems.

The entire DR-5 P&T system was shut down for the month of January to transfer extraction well 199-D5-32 to well 199-D5-104. Otherwise, total system pumping rates remained relatively constant throughout CY 2010. Figure 2-19 shows the system availability for the reporting period. At DR-5, high hexavalent chromium effluent concentrations resulted in unplanned downtime of 71 hours in February, 378 hours in March, 198 hours in April, and 128 hours in June. Downtime of 15 hours in April and 0.4 hours in May resulted from a high reading on the differential pressure transducer, followed by 136 hours in July due to a universal power supply failure and an additional 56 hours in July resulting from an anomaly with a tank pressure switch. In November, there were 7.3 hours of electrical power loss, followed by 166 hours of frozen transfer lines, which continued for 132 additional hours in early December.

### **2.3.2.3 Compliance Monitoring**

The DR-5 P&T system currently does not have any compliance wells; however, the system is monitored on a regular basis.

### **2.3.3 Hydraulic Capture**

The following subsections describe groundwater flow and the extent of capture estimated for the 100-D and 100-H Areas during CY 2010. Groundwater levels are measured throughout the 100-D and 100-H Areas continuously at some wells using pressure transducers with data loggers and on a regular basis at other wells using manual (depth-to-water) measurements. Groundwater elevations indicate that flow is generally toward the Columbia River, but the rates and directions of flow are affected by pumping associated with the P&T remedies. Consistent with recommendations in the U.S. Environmental Protection Agency's (EPA's) *A Systematic Approach for Evaluation of Capture Zones at Pump-and-Treat Systems, Final Project Report* (EPA/600/R-08/003), multiple lines of evidence are used to estimate capture. The two methods used here are (1) water-level mapping, and (2) groundwater modeling. These methods are further described in Appendix C.

### 2.3.3.1 100-H Area Approximate Flow Patterns and Extents of Capture

Figure 2-20 summarizes the pumping rates in the 100-H Area. Individual wells were shut off intermittently for periods of days to weeks, and the entire system was shut down for a 3-week period from mid-July to early August 2010. Otherwise, total system pumping rates remained relatively constant throughout CY 2010. Rates at individual wells were adjusted as some wells came online and other wells were shut down to accommodate changing plume conditions and address higher hexavalent chromium concentrations identified in the first water-bearing layer of the RUM: well 199-H4-3 came online in early May; wells 199-H4-18, 199-H4-12C, and 199-H3-2C came online in August; well 199-H4-12A was shut down in mid-June; and well 199-H4-4 was offline for most of CY 2010.

Figure 2-21(a and b) provides example water-level contours for the 100-H Area during for high and low river-stage conditions (the weeks of May 30 and September 26, 2010, respectively). Multiple maps analogous to those presented in Figure 2-21 were constructed using weekly averaged water levels obtained from January to October 2010 with transducers and corresponding weekly pumping rates. These weekly maps were used to calculate a capture frequency map (CFM) depicting the extent of hydraulic capture developed by the 100-H Area remedy during that 10-month period. Maps representing November to December were not included because some of monitoring data were inconsistent or missing due to equipment failures and freezing conditions. The CFM is supplemented by a capture efficiency map (CEM) calculated using the 100 Area groundwater model. Figure 2-21(a and b) illustrates the changes in flow direction and gradients in response to changes in river stage. For most of the year, gradients are relatively steep and flow is toward the Columbia River (Figure 2-21[b]). From April to June, the river stage rises and gradients become less steep, as shown in Figure 2-21(a). During the highest river stage, May and June, gradients reverse and flow is generally inland, away from the river. Figure 2-22 presents Columbia River stage with water elevation in several monitoring wells. These hydrographs suggest that gradient reversals begin near the river shoreline around mid-April and extend across the 100-H Area by mid-June. Typical flow direction toward the river resumes in late June/early July.

Figure 2-23(a) depicts the CEM for the HR-3 P&T system from January through October 2010 determined using the groundwater model. Figure 2-23(a) represents the combination of 10 instantaneous monthly capture zone estimates. Figure 2-23(b) depicts the CFM for the HR-3 P&T system from January through October 2010 determined using the mapping approach. Figure 2-23(b) represents the combination of 45 weekly averaged water-level and pumping rate data sets. Figure 2-24(a and b) shows the same estimated extents of hydraulic capture developed by the HR-3 P&T system as shown in Figures 2-23(a and b), overlaid with contours that illustrate the extent of hexavalent chromium in groundwater during spring 2010. Fall 2010 contours were not developed because insufficient data were collected due to stop work order that was in effect for about 6 weeks starting in October, as previously discussed.

Review of Figure 2-23(a and b) suggests that the approximate extents of capture calculated using the mapping method and the groundwater model for the HR-3 P&T system are similar in appearance, although some areas differ. The overlays of the CEM and CFM maps with the contoured extents of hexavalent chromium (Figure 2-24[a and b]) identify areas where capture is satisfactory and where capture is unsatisfactory. The following observations can be made:

- The CEM and CFM provide a fairly consistent interpretation of the extent of capture developed by the HR-3 system from January through October 2010.
- Both methods consistently suggest that the capture is incomplete in the following areas:
  - Upgradient of the current 100-H Area extraction wells.

- Downgradient of wells 199-H4-18, 199-H4-4, 199-H4-12A/12C, and 199-H4-64. Concentrations in these areas are typically between 10 and 20  $\mu\text{g/L}$ , which exceeds the aquatic water quality criterion of 10  $\mu\text{g/L}$ .
- Capture in these areas will increase following startup of the HX system, scheduled for late 2011.

The CEM and CFM approaches show different capture effectiveness in some areas resulting from a combination of (1) the variable distribution of water-level monitoring, (2) the different periods used in preparing the CEM and CFM maps (as described above), and (c) differences in the methods used. Differences arising from monitoring density and contrasting periods used can be practically addressed prior to the next reporting period. Differences between the methods are expected to be limited when the monitoring network is optimized and comparable summary periods are used in the analyses.

### **2.3.3.2 100-D Area Approximate Flow Patterns and Extents of Capture**

Figures 2-25 and 2-26 summarize pumping rates in the two 100-D Area P&T systems: the DR-5 P&T system, and the “D-8” wells from the HR-3 P&T system. Total pumping rates remained relatively constant in both systems throughout CY 2010, but individual wells were offline intermittently for periods of days to weeks. The entire DR-5 P&T system was shut down for the month of January, and the entire HR-3 P&T system was shut down for 3 weeks from mid-July to early August. Extraction rates in both systems remained relatively steady in all wells. Injection rates in the DR-5 system were not available, so the injection volume was assumed to equal the extraction volume and weekly injection rates were estimated accordingly. Well 199-D5-42 was taken offline from February 11 to September 22, 2010, for rehabilitation. During this time, injection was through well 199-D5-41 only. From September 22 until the end of CY 2010, injection was divided evenly between wells 199-D5-41 and 199-D5-42.

Figure 2-27(a and b) shows water-level contours for the 100-D Area for high and low river-stage conditions (the weeks of May 23, 2010, and September 5, 2010, respectively). Multiple maps analogous to those presented in Figure 2-27(a and b) were constructed using weekly averaged water levels obtained from January through October 2010 with transducers and corresponding weekly pumping rates. The weekly maps were used to calculate a CFM depicting the extent of hydraulic capture developed by the combined 100-D Area systems during the 10-month period. Maps generated for November through December were not included because some monitoring data were lost to transducer failures and freezing, and because testing related to the DX P&T system startup resulted in highly variable water-level measurements in nearby monitoring wells that were not representative of aquifer conditions. The CFM is supplemented by a CEM calculated using the 100 Area groundwater model. Figure 2-27(a and b) illustrates the changes in flow direction and gradients in response to changes in river stage. For most of the year, gradients are relatively steep and flow is toward the Columbia River (Figure 2-27[b]). During high river stage (May and June), gradients are less steep. Flow direction becomes more parallel to the river and begins to reverse (Figure 2-27[a]). Figure 2-28 presents the Columbia River stage with water elevation in several monitoring wells. These hydrographs suggest that the gradient is reversed and flow is inland, away from the river, for much of late May and June. Typical flow direction toward the river resumes in late June/early July.

Figure 2-29(a) depicts the CEM for the combined 100-D Area systems (DR-5 and D transfer) from January through October 2010 determined using the groundwater model. Figure 2-29(a) represents the combination of 10 instantaneous monthly capture zone estimates. Figure 2-29(b) depicts the CFM for the 100-D Area systems from January through October 2010 determined using the mapping approach. The CFM for the DR-5 system represents the combination of 38 weekly averaged water-level and pumping rates measured during system operation, and the CFM for the HR-3/D-8 system represents the combination of 42 weekly averaged water-level and pumping rates measured during system operation.

Figure 2-30(a and b) shows the same estimated extents of hydraulic capture developed by the 100-D Area systems as shown in Figure 2-29(a and b), overlaid with contours that illustrate the extent of hexavalent chromium in groundwater during spring 2010.

Review of Figure 2-29(a and b) suggests that the approximate extents of capture calculated using the mapping method and the groundwater model for the combined 100-D Area systems are similar, although there are clear differences. Overlays of the CEM and CFM maps with the contoured extents of hexavalent chromium (Figure 2-30[a and b]) identify areas where capture is satisfactory and where capture is unsatisfactory. Noting that the CEM calculated using the model (Figures 2-29[a] and 2-30[a]) depicts capture throughout the period January through October 2010, while the CFMs calculated using the mapping method represent periods when each system was operating (Figures 2-29[b] and 2-30[b]), the following is evident:

- The CEM and CFM provide for a reasonably consistent interpretation of the extent of capture developed by the 100-D Area systems throughout the contoured extent of hexavalent chromium above approximately 100 µg/L.
- In the east (upgradient) portion of the area, the mapped CFM suggests higher capture frequencies than the modeled CEM. Since both of the CFM and CEM maps are constrained by monitored water levels, the difference is expected to be due to a lack of monitoring data to constrain either analyses in the area and can be improved with the installation of one or more upgradient transducers/data loggers.
- When the 100-D Area systems (DR-5 and D transfer) are operating, the high capture frequencies calculated by the mapping method and high capture efficiencies calculated using the model encompass the majority of the contoured extent of hexavalent chromium above a concentration of approximately 100 µg/L, with the exception of hexavalent chromium that lies downgradient of well 199-D5-39 (which is partially remediated by the ISRM barrier).
- In CY 2011, the CEM and CFM will include DX system operation for a full year, as well as HX system operation for the last quarter of the CY. This should significantly improve the zone of capture.

The CEM and CFM approaches show different capture effectiveness at lower concentrations, between about 10 and 100 µg/L, due to a combination of (1) the variable distribution of water-level monitoring, (2) the different periods used in preparing the CEM and CFM maps (as described above), and (3) differences in the methods used. Differences arising from monitoring density and contrasting periods used can be practically addressed prior to the next reporting period. Differences between the methods are expected to be limited once the monitoring network is optimized and comparable summary periods are used in the analyses. Both the CEM and CFM are expected to show improved capture since startup of the DX system in December 2010.

### **2.3.3.3 DX and HX Pump-and-Treat Systems**

An RPO evaluation began in 2008 to determine how best to optimize the remediation of hexavalent chromium in the 100-HR-3 OU groundwater by 2012 (SGW-38338). The RPO approach is a systematic process for evaluating existing remediation systems, with the goal of improving their effectiveness and reducing overall site cleanup costs without increasing risks. In the long run, efficient use of RPO reduces the operations and management burden. The RPO review recommended implementing additional P&T system capacity to address the hexavalent chromium groundwater concentrations that still exceed the cleanup levels established in the interim ROD (EPA/ROD/R10-96/134) and interim ROD amendment (EPA/AMD/R10-00/122). The new DX and HX P&T systems will substantially increase the rate of

groundwater cleanup in the 100-HR-3 OU (DOE/RL-2009-56, *Remedial Design Report and Remedial Design/Remedial Action Work Plan for the 100-HR-3 Groundwater Operable Unit Interim Action*).

The RPO efforts have focused on addressing protection of the Columbia River and achieving plume remediation. These efforts have also looked at reducing costs and improving performance of the existing systems. The following RPO tasks have been completed:

- Reviewed and summarized the conceptual site model and discussed implications for site remediation
- Reviewed the design and performance of existing ex situ remedial systems and treatability actions; identified system or process modifications to improve performance
- Identified and screened in situ and ex situ remedial technologies with the potential to improve remedial performance at the site
- Developed and summarized potential remedial action alternatives for the site based on the screened technologies
- Developed pre-conceptual designs and costs for three P&T technologies that were identified during the screening process as candidates for inclusion into one or more of the remedial action alternatives
- Developed pre-conceptual level designs and costs for the remedial action alternatives and screen the remedial action alternatives using appropriate decision analysis tools that incorporate CERCLA for evaluation

The following RPO task is under development:

- Develop a process and control optimization plan for the iterative and continuing optimization of the DX/HX P&T systems (DOE/RL-2009-56)

Under the RPO work plan, the DX and HX P&T systems will constantly evolve while groundwater remediation activities continue toward meeting Tri-Party Agreement remediation goals. To manage and refine the DX and HX systems, the RPO process will use available source area data; groundwater monitoring data, including compliance wells; updated contaminant fate and transport modeling results; and extraction/injection well performance data. Action items may include installing additional extraction/injection wells, converting injection wells to extraction wells (or vice versa); changing extraction/injection rates; and addressing source areas to remove contaminant contributions to groundwater. The plan will also address transient river-stage effects that could impact the ability of the DX and HX P&T systems to hydraulically control the contaminant plume and effectively reduce contaminant mass in the aquifer.

Seventy new RPO extraction/injection wells were installed within the 100-HR-3 OU to further aid in groundwater remediation activities (Figures 2-31 and 2-32). To accommodate the additional extraction well production needed to capture the full extent of the plume in the 100-D Area and western portion of the horn area, the DX system was completed at the end of CY 2010. This system will be capable of treating groundwater at up to 2,300 L/min [600 gpm]. Pilot testing of the DX system began in December 2010; in one month, the system treated approximately 55.3 million L (14.6 million gal) of groundwater and removed an additional 18.4 kg of hexavalent chromium. Construction of the HX system (3,000 L/min [800 gpm]) is progressing ahead of schedule, with startup anticipated in December 2011.

Groundwater from the 100-D Area portion of the HR-3 P&T system continued to be piped to the 100-H Area for treatment. As an outcome of the RPO, the DOE has begun consolidating extraction, treatment, and injection within the two areas to reduce water movement across the horn area.

### **2.3.4 In Situ Redox Manipulation System**

A PRB for in situ chemical treatment of the hexavalent chromium in the southern plume (100-D Area) was emplaced as an interim remedial action in accordance with the interim ROD amendment (EPA/AMD/R10-00/122) beginning in 2000 (Figure 2-33). The reduction-oxidation treatment zone is approximately 680 m (2,230 ft) long (aligned parallel to the Columbia River) and approximately 100 to 200 m (330 to 660 ft) inland and consists of 65 wells spaced across almost the entire width of the southern hexavalent chromium plume. The treatment zone was designed to reduce the concentration of hexavalent chromium in groundwater to no more than 20 µg/L at seven compliance wells located between the treatment zone and the Columbia River.

The PRB uses ISRM technology to create a treatment zone in which ferric iron (iron[III]) is reduced to ferrous iron (iron[II]) within the aquifer matrix. This is accomplished by injecting sodium dithionite into the aquifer through wells, then withdrawing the unreacted reagent and reaction products (predominately sulfate) through the same wells and pumping to the ISRM evaporation pond. The sodium dithionite serves as a reducing agent for iron, producing a reducing-type environment in the aquifer. As the groundwater migrates through the treatment zone, the mobile hexavalent chromium is reduced to the less toxic, immobile trivalent chromium, which precipitates from solution. Dissolved oxygen (DO) and some nitrate are also removed from the groundwater as it passes through the PRB.

The barrier is discussed in this report in order to provide a consolidated discussion of all interim remedies that are being used in the River Corridor. A notice of nonsignificant change to the ROD was issued in 2010 that indicated the barrier no longer will be actively maintained (Holten, 2010).

#### **2.3.4.1 Hydraulic Monitoring**

Groundwater elevations in the unconfined aquifer were measured in monitoring wells at and surrounding the ISRM site in CY 2010. The water levels were measured using an automated recording system and were supplemented by quarterly manual measurements using an electric tape, and then comparing the measurements to known survey elevations. The height of the Columbia River is also monitored electronically at the 100-D Area river gauge, located directly north of the ISRM barrier. The automated water-level network recorded data from pressure transducers at 17 locations on an hourly basis.

Groundwater flow in the 100-D Area is relatively stagnant compared to the 100-H Area. Water levels in the 100-D Area are similar to water levels in the regional flow field to the south. Regional flow entering the southern portion of the 100-HR-3 OU tends to flow toward the 100-H Area leaving the 100-D Area, to the edge of regional groundwater flow streamlines. River elevation can vary as much as 3.2 m (10.5 ft) throughout the year. During low river stage (September through December), groundwater flow is generally toward the river. During the spring (April through June), high levels in the Columbia River create flow from the river inland, with a steeper gradient near the river and flattening somewhat further inland. This mechanism may have allowed chromium to build up for years in the aquifer based on the current observed hot spot upgradient of the ISRM barrier.

Groundwater flow is also affected by the P&T system. Small groundwater mounds are present due to injection of treated groundwater from the DR-5 P&T system. A small number of groundwater depressions were observed around the DR-5 system extraction wells.

#### **2.3.4.2 Compliance Monitoring**

Groundwater at the ISRM site is sampled as part of CERCLA interim action monitoring, and hexavalent chromium is the COC. As required by the sampling documents, DO is also monitored. The barrier treatment process reduces oxygen content in the aquifer. Groundwater with depleted DO levels could

potentially harm aquatic receptors. Other groundwater constituents and properties are also monitored to better understand the chemical characteristics of the plume.

The ISRM barrier (Figure 2-34) intersects the southern hexavalent chromium plume and has largely cut off the highest concentration portion of the plume and prevented it from extending to the Columbia River. Figure 2-35 shows hexavalent chromium concentration plots for the ISRM compliance wells. The CY 2010 hexavalent chromium concentrations were all below the 20 µg/L remedial action goal in southernmost compliance well 199-D4-86, with a maximum measurement of 14.3 µg/L. The compliance monitoring wells in the northwestern portion of the ISRM barrier generally had higher hexavalent chromium concentrations in the northeast portion of the barrier during the reporting period. The most northeastern well, 199-D4-83, had levels of hexavalent chromium up to 109 µg/L in 2010, which is an increase from the CY 2009 maximum concentration of 95.8 µg/L. Groundwater in well 199-D4-39, also near the northeastern end of the barrier, had hexavalent chromium levels ranging from 798 to 2,960 µg/L in CY 2010; these levels show higher variance than the range of 515 to 783 µg/L observed in CY 2009. Concentrations remained above the remedial action goal in wells 199-D4-38 and 199-D4-84 (downgradient from the central portion of the ISRM barrier) with maximum concentrations of 116 and 69 µg/L, respectively. Remedial action monitoring is described in the *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 Groundwater Operable Unit In Situ Redox Manipulation* (DOE/RL-99-51).

Figure 2-36 shows hexavalent chromium concentrations in the ISRM barrier for the first three quarters of CY 2010. The histograms in the figure show that hexavalent chromium concentrations are lowest in the third quarter. In the first quarter (samples taken in February), fewer barrier wells were below the RAO of 20 µg/L, primarily because groundwater flow is predominately toward the river and the hydraulic gradient was the highest; this allows less time for groundwater to react with reduced sediments in the ISRM barrier. Conversely, when the river stage is high and groundwater gradients are reversed (i.e., groundwater flow is inland from the river), water has a longer residence time in the barrier and/or previously treated water flows back to the barrier, so more hexavalent chromium is reduced to trivalent chromium. The northeastern half of the barrier continues to have the greatest number of wells with concentrations greater than 20 µg/L. Overall barrier performance in CY 2010 was slightly less effective than observed in CY 2009. The percentage of barrier monitoring wells below the RAO averaged 57 percent during CY 2010 compared to 60 percent for CY 2009.

The DO concentrations are monitored as required by the ROD amendment (EPA/AMD/R10-00/122) and the remedial design report/remedial action work plan (DOE/RL-99-51). The sodium-dithionite injection process reduced DO in the groundwater at the barrier to low levels. Low levels of DO are monitored to assess changes in concentration as groundwater approaches the Columbia River. The DO profile near the ISRM treatment zone is generally characterized by relatively high DO concentrations upgradient of the treatment zone, decreasing significantly through the treatment zone, and recovering to higher DO concentrations as groundwater flow approaches the river (Figure 2-37). A comparison was made between several wells in a line located upgradient of the ISRM (199-D4-15 and 199-D4-20), wells within the ISRM (199-D4-3 and 199-D4-19), and wells downgradient of the ISRM (199-D4-23 and 199-D4-84).

Since minimal data were collected in fall 2010, the DO sampling results from April through July were compared. The east line of wells moving from upgradient to downgradient (199-D4-15 [8,920 µg/L], 199-D4-3 [3,860 µg/L], and 199-D4-23 [4,640 µg/L]) shows a reduction in oxygen of approximately 50 percent, with a slight increase moving downgradient. The west line of wells moving from upgradient to downgradient (199-D4-20 [4,140 µg/L], 199-D4-19 [1,220 µg/L], and 199-D4-84 [1,620 µg/L]) shows a reduction in oxygen of approximately 70 percent, with a slight increase as moving downgradient. Based on these results, it is evident that the ISRM barrier continues to create favorable conditions for

reducing hexavalent chromium. This system, together with the downgradient DX system extraction wells, will aid in meeting remedial action goals. However, it is also important to note that the reduction in DO can result in negative impact to aquatic organism; there is a requirement to address this via air sparging or other means if significant low values persist.

Sulfate is a byproduct of the sodium-dithionite reaction used to establish the ISRM treatment zone. It is also listed as a groundwater contaminant with a national secondary DWS of 250 mg/L (40 CFR 143, "National Secondary Drinking Water Regulations"). Sulfate concentrations exceeded the secondary DWS in two areas located at the southwestern portion of the ISRM barrier and downgradient from the barrier (Figure 2-34). A summary of the sulfate results for wells influenced by the ISRM barrier during CY 2010 is presented below:

- Sulfate concentrations in groundwater underlying much of the 100-D Area remained above 100 mg/L.
- Overall, the sulfate concentrations in CY 2010 were comparable to CY 2009, with most wells showing stable or slightly decreasing concentrations.
- Sulfate concentrations in wells ranged from 1.3 to 437 mg/L.
- Two wells and two aquifer tubes had sulfate concentrations exceeding the secondary MCL of 250 mg/L:
  - Downgradient compliance well 199-D4-84 (increasing concentration trend)
  - One treatment zone injection/monitoring well (199-D4-78)
  - Aquifer tubes DD-42-4 (616 mg/L) and DD-43-3 (776 mg/L), which have historically had the highest detected sulfate concentrations.

All of the 100-D Area wells are sampled quarterly for pH, which generally ranges from 7.0 to 8.3, although some values greater than 9 are reported. Monitoring pH is an important component in ISRM barrier performance; trivalent and hexavalent chromium speciation in the aquifer depends on both pH and oxidation-reduction potential (ORP). While the scoping studies for the barrier stressed the importance of maintaining basic pH levels greater than 7 for optimum barrier performance, it is possible that excessively high pH may be counterproductive, given that hexavalent chromium is the predominant species for pH greater than approximately 8.5 and for ORP of greater than 0.3 volts. Three of the wells with pH greater than 9 (199-D4-26, 199-D4-92, and 199-D4-93) are monitoring wells located in the original ISRM treatability test area, and one well (199-D8-88) is located near the Columbia River several hundred meters to the northeast of the barrier.

## 2.4 Additional Investigations

This section summarizes additional investigations at the 100-HR-3 Groundwater OU during CY 2010.

### 2.4.1 Aquifer Testing and Rebound Study

The second CERCLA 5-year review report for the Hanford Site (DOE/RL-2006-20) set a milestone to conduct an investigation of deep hexavalent chromium contamination in the sediments of the RUM, which underlies the unconfined aquifer in the 100-H Area (SGW-47776). The second 5-year review noted that groundwater samples from one deep well extending below the aquitard (i.e., below the top of the RUM) exceeded both the groundwater standard of 48 ppb (Washington State Department of Ecology [Ecology] Publication 94-06, *Model Toxics Control Act Cleanup Regulation 173-340 WAC*) and the federal DWS of 100 µg/L for hexavalent chromium. The extent of hexavalent chromium contamination in

this zone is not well understood. In response to these observations, Action 12-1 from the CERCLA 5-year review was to “perform additional characterization of the aquifer below the initial aquitard.”

Field characterization and aquifer testing were performed in the 100-H Area to address this milestone. In particular, aquifer tests were conducted to gather data to answer several fundamental questions regarding the presence of the hexavalent chromium in the deep sediments of the RUM and determine the extent and magnitude of deeper contamination. The pumping tests were performed in accordance with the *Description of Work for Aquifer Testing in Support of the 100-H Deep Chromium Investigation* (SGW-41302). The specific objectives for the series of tests were as follows:

- Evaluate the sustainable production of the subject wells using step-drawdown and constant-rate pumping tests.
- Collect water-level data to evaluate the degree of hydraulic connection between the RUM and the unconfined (upper) aquifer (natural or induced along the well casing).
- Evaluate the hydraulic properties of the first water-bearing layer within the RUM.
- Collect time-series groundwater samples during testing to evaluate the extent and persistence of hexavalent chromium in the deeper zones. Use data collected to refine the current conceptual model for the 100-H Area unconfined aquifer and the RUM in this area.
- Evaluate the concentration rebound in the unconfined aquifer of hexavalent chromium and the COCs during shutdown of the extraction wells. Measure co-contaminants at the beginning, middle, and end of each pumping test.

The RUM is generally considered an aquitard in the 100-HR-3 OU; however, several water-bearing sand layers are present and confined within the RUM. The current hydrogeologic model for the 100-H Area aquifer system portrays the RUM as an aquitard layer that underlies the unconfined aquifer, which may contain permeable zones, stringers, or layers. These permeable layers may provide pathways for chromium to migrate deeper into the RUM under certain hydrogeologic conditions.

Persistent chromium concentrations were observed during the tests, suggesting a large-scale emplacement of chromium. The concentration decreases upgradient toward the horn area, suggesting a limit on the eastward extent of contamination. This is consistent with the results of the horn area investigation, which found locations in the same horizon in the horn area without any chromium contamination. The potential for bad well construction generating the steady, persistent concentrations produced during the test seems unlikely, particularly given the upward groundwater gradient in the study area.

The results of this study, in conjunction with the recent horn area investigation (DOE/RL-2008-42), suggest that the most likely explanation for the presence of hexavalent chromium in the RUM underlying the 100-H Area is contaminated cooling water that passed through the H Reactor. This cooling water contained up to 1,000 µg/L of hexavalent chromium that was subsequently discharged to the ground in sufficient quantities to form a mound that provided sufficient hydraulic driving force to push into the upper RUM and mix with existing groundwater in the RUM, resulting in concentrations of one-tenth to one-thirtieth of the original cooling water. Concentrations decline inland, which is consistent with a reactor mound. The areal extent and relatively high continuous concentrations rule out localized contamination during well drilling.

## 2.4.2 Remedial Investigation/Feasibility Study Characterization and Integration with Interim Actions

During CY 2010, the RI/FS work plan addendum for the 100-D/H Area (DOE/RL-2008-46-ADD1) and the sampling and analysis plan (DOE/RL-2009-40) were approved by the lead regulatory agencies. These two documents identify the data to be collected to support selection of final remedies under CERCLA using an approach that integrates data needs for waste sites and groundwater. A total of 10 boreholes, 15 groundwater wells, 5 test pits, and 6 aquifer tubes were proposed for installation in CY 2010 and CY 2011 under the work plan. In addition, 53 existing groundwater wells were scheduled for three sampling rounds. The field work is scheduled for completion by April 2011. At the end of CY 2010, progress was underway and the following work was completed:

- Seven of 15 wells were drilled and sampled.
- Two of 10 boreholes were drilled and sampled.
- Two of five test pits were installed.
- All aquifer tubes were installed and sampled.
- Three sampling rounds for temporal spatial analysis of 53 wells were completed (the first sample round occurred in 2009). The analytical results for these wells are included in discussions, tables, and figures within this report.

The scheduled RI/FS activities were not completed before preparation of this annual report. Therefore, the complete data set from these investigations will be fully evaluated and reported in the RI/FS report, which will lead to the selection of alternatives for final cleanup action. The RI/FS report is scheduled for submittal later in CY 2011. Preliminary highlights of RI/FS findings are briefly summarized below:

- **Soil – 100-D and 100-H Areas:**

- Preliminary soil sampling results indicate that total chromium concentrations are much higher than hexavalent chromium concentrations. Concentrations of other contaminants of potential concern do not show significant concentration variations from previous investigations.

- **Groundwater – 100-D Area:**

- Hexavalent chromium concentrations in borehole characterization groundwater samples from RI/FS wells generally fall within expected values, exceeding the ambient water quality criterion value of 10 µg/L and the *Model Toxics Control Act* (MTCA) (WAC 173-340, “Model Toxics Control Act – Cleanup”) value of 48 µg/L. The only unexpected concentrations area associated with well 199-D3-5, which is near the former 116-D-1A Burial Ground. This well was installed to define the southwestern extent of hexavalent chromium in the unconfined aquifer but actually shows increasing concentrations on top of the RUM.
- Hexavalent chromium concentrations in the unconfined aquifer are generally homogeneous throughout the unconfined aquifer. However, in groundwater samples from wells 199-D5-133 and 199-D3-5, hexavalent chromium concentrations are higher at the water table and on top of the RUM, respectively.
- Total chromium concentrations in groundwater samples collected at the same depth interval are generally higher than hexavalent chromium concentrations. Although this trend is opposite in borehole unconfined water samples collected from wells placed within the center of the south

(199-D5-141) and north (199-D5-134) plumes. Hexavalent chromium concentrations are higher than total chromium in these wells.

- Nitrates in borehole water samples from the unconfined aquifer exceeded the DWS (45,000 µg/L) in wells 199-D5-141, 199-D5-134, 199-D5-140, 199-D6-3, 199-D5-132, 199-D5-133, and 199-D3-5.
- Strontium-90 concentrations in groundwater samples collected from boreholes were all below the 8 pCi/L DWS, excluding wells 199-D3-5 and 199-D5-132. Well 199-D5-132 is located near remediated waste site 116-D-1A. The extent has been defined with other existing monitoring wells within the area. Well 199-D3-5 is located downgradient of former waste burial site 118-D-2.
- Technetium-99 concentrations in borehole groundwater samples were below the minimum detection limit (MDL) and/or DWS for all samples collected from the 100-D Area.
- Tritium concentrations in borehole groundwater samples were below the MDL and/or DWS (20,000 pCi/L) for all samples collected from the 100-D Area.
- Uranium concentrations in borehole groundwater samples were below the MDL and/or DWS (30 µg/L) for all samples collected from the 100-D Area.
- Zinc concentrations in borehole groundwater samples collected from wells 199-D5-134 (unconfined aquifer and RUM), 199-D5-133, 199-D5-140, and 199-D6-3 exceeded the action level of 91 µg/L. The remaining “D” wells were below the action level.
- Two RUM wells were installed within the north and south hexavalent chromium plumes. The borehole samples collected from each of these wells within the RUM showed impact within the first water-bearing layer at concentrations exceeding the ambient water quality criterion but below the MTCA standard. However, hexavalent chromium concentrations samples from lower water-bearing layers were below the laboratory method detection limits. Nitrate, strontium-90, technetium-99, and tritium were below their respective DWSs. Uranium concentrations were low, and zinc concentrations appeared excessive in the sample from the first water-bearing layer at 331 µg/L.

- **Groundwater – 100-H Area:**

- Generally, the chromium concentrations in borehole groundwater samples from RI/FS wells in the unconfined aquifer are rather low. Samples collected from wells 199-H6-4, 199-H6-3, 199-H3-7, 199-H3-6, 199-H3-9, and 199-H2-1 are either below or slightly elevated above the ambient water quality criterion. None of the groundwater samples collected from the unconfined aquifer exceeded the MTCA value.
- Total chromium concentrations in groundwater from borehole samples are generally higher than the hexavalent chromium concentrations in the same sample. However, none of the groundwater samples collected from the unconfined aquifer exceeded the MTCA value.
- Strontium-90 was detected above the DWS in the borehole groundwater sample from only well 199-H3-6. The remaining wells did not have strontium-90 detected in samples or were below the MDL.
- Nitrate concentrations in borehole groundwater samples were below the DWS for all samples collected from the 100-H Area.

- Technetium-99 concentrations in borehole groundwater samples were below the MDL and/or DWS for all samples collected from the 100-H Area.
- Tritium concentrations in borehole groundwater samples were below the MDL and/or DWS for all samples collected from the 100-H Area.
- Uranium concentrations in borehole groundwater samples were below the MDL and/or DWS (30 µg/L) for all samples collected from the 100-H Area.
- Zinc concentrations in borehole groundwater samples collected from wells 199-H2-1 (unconfined aquifer and RUM) and 199-H6-3 exceeded the action level of 91 µg/L. The remaining “H” wells were below the action level.
- The northern extent of hexavalent chromium in the first water-bearing layer in the RUM is defined by well 199-H2-1, as the sample was below the ambient water quality criterion. However, the groundwater sample from well 199-H3-9 collected within the first water-bearing layer in the RUM had the highest concentration of hexavalent chromium identified in groundwater underlying the 100-H Area. The vertical extent of impacts is defined with the next deeper water sample.

### 2.4.3 Dense Chromium Study

A dense chromium study was initiated at the end of CY 2010. The purpose of this study was to collect groundwater samples from various depths in monitoring wells using a passive sampler to evaluate the existence and significance of any vertical change in hexavalent chromium concentrations. Well locations were selected based on their relative proximity to potential hexavalent chromium source areas and the current concentrations identified in recent groundwater samples. The southern and northern plumes underlying the 100-D Area were the focus of this study; however, one well within the horn area was also sampled for comparison.

The sampling was conducted using four passive diffusion samplers located at specific depths within each monitoring well (199-D5-99, 199-D5-122, 199-D5-126, and 699-97-45). The samplers are small cylinders of rigid, porous polyethylene, 12.7 cm (5 in.) tall and 1.9 cm (1.5 in.) in diameter, containing 100 mL of deionized water. The samplers are attached to a cable at specific intervals down the well and allowed to equilibrate for a minimum of 14 days. The samplers were installed between December 17-29, 2010.

Preliminary results indicated stratification in some wells and not in others. Well 199-D5-99 showed relatively consistent concentrations of 1,400 to 1,500 µg/L in the upper three samplers and 10,000 µg/L in the lower sampler. Well 199-D5-122 showed approximately 6,500 µg/L in the upper sampler and 26,000 µg/L in the lower three samplers. Well 199-D5-126 showed approximately uniform concentrations of 1,500 µg/L in all four samplers. Well 699-97-45 showed concentrations between 50 and 60 µg/L in the upper three samplers and 25 µg/L near the bottom of the aquifer. The results of the study will be evaluated in CY 2011.

## 2.5 Conclusions

The general conclusion for the 100-HR-3 OU is as follows:

- The DR-5, HR-3, and ISRM remedies are actively working toward achievement of the RAO. The RAO will be met with implementation of the DX P&T system that is now operational and the HX P&T system scheduled to be online later in 2011. These additional remedies will reduce hexavalent chromium concentrations in groundwater before they can reach the Columbia River.

The conclusions with respect to each RAO are discussed below:

- **RAO #1:** Protect aquatic receptors in the river bottom substrate from contaminants in the groundwater entering the Columbia River.

#### **100-D Area:**

- During CY 2010, the DR-5 P&T system extracted 44.6 million L (11.8 million gal) of groundwater from the 100-D Area, which is an 8 percent decrease when compared to 48.6 million L (12.8 million gal) processed in CY 2009. The system removed 74.9 kg of hexavalent chromium during the reporting period, for a total of 326.2 kg removed and more than 375 million L (99.1 million gal) since 2004.
- In CY 2010, hexavalent chromium concentrations were above the 20 µg/L remedial action goal in both compliance wells (199-D8-69 and 199-D8-70). Well 199-D8-69 has since been converted into an extraction well for the DX P&T system, which should reduce hexavalent chromium concentrations within this portion of the unconfined aquifer.
- Overall, the ISRM barrier continues to help reduce hexavalent chromium in the aquifer. However, during periods of low flow, hexavalent chromium values above the RAO were observed in some downgradient wells, which increased in concentration since 2009. However, downgradient DX extraction wells now exist to compensate for ISRM breakthrough, which will reduce hexavalent chromium concentrations in groundwater before reaching the Columbia River.

Operational monitoring of treatment zone (barrier) wells indicates that low chromate concentrations and generally reducing conditions persist in the majority of the ISRM barrier, particularly in the southwestern portion of the barrier. The northeastern half of the barrier continues to have the greatest number of wells with concentrations greater than 20 µg/L. Overall, the barrier's performance in CY 2010 was slightly less effective than observed in CY 2009. The percentage of barrier monitoring wells below the RAO averaged 57 percent during CY 2010 compared to 60 percent for CY 2009.

- The effect of high river stage during the early summer months provides a natural hydraulic barrier for movement of the hexavalent chromium plume to the Columbia River.

#### **100-H Area:**

- In CY 2010, the HR-3 P&T system extracted 267.9 million L (70.8 million gal) of groundwater from the 100-HR-3 OU. This is a 51 percent increase in volume compared to CY 2009 due to the aquifer testing and rebound study. The system removed 31 kg of hexavalent chromium during CY 2010, for a total amount of 400 kg and 4.05 billion L (1.07 billion gal) removed since 1997.
- During CY 2010, hexavalent chromium concentrations were less than the 20 µg/L remedial action goal in two of four original compliance wells (199-H4-5 and 199-H4-13). A May 2010 groundwater sample from well 199-H4-11 had a hexavalent chromium detection of 21.6 µg/L, with the March and December samples less than 20 µg/L. The groundwater sample from well 199-H4-10 fluctuated between slightly exceeding and being less than the RAO. Groundwater samples from all four compliance wells continue to show decreasing hexavalent chromium concentration trends.
- In CY 2010, hexavalent chromium concentrations were greater than the 20 µg/L remedial action goal in HR-3 system extractions wells 199-H4-64 (26 µg/L) and 199-H4-15A (31 µg/L).

Wells 199-H4-15A and 199-H4-64 will be incorporated as extraction wells in the new HX P&T system to continue remediation.

- Aquifer testing of the first water-bearing layer within the RUM indicates that hexavalent chromium concentrations were higher in RUM wells than in unconfined wells 199-H4-12A and 199-H4-15A (SGW-47776).
- The effect of high river stage during the early summer months provides a natural hydraulic barrier for movement of the hexavalent chromium plume to the Columbia River.

**Horn area:**

- The last of the RPO wells were installed in 2010 to remediate groundwater underlying this area. The newly installed wells and aquifer tubes likely confirm that a low-concentration hexavalent chromium plume (less than 100 µg/L) originating from the 100-D Area underlies the horn area.
- **RAO #2:** Protect human health by preventing exposure to contaminants in the groundwater.
  - The interim remedial ROD (EPA/ROD/R10-96/134) establishes a variety of institutional controls that must be implemented and maintained throughout the interim action period. These provisions include the following:
    - Access control and visitor escorting requirements
    - Signage providing visual identification and warning of hazardous or sensitive areas
    - Excavation permit process to control all intrusive work (e.g., well drilling and soil excavation)
    - Regulatory agency notification of any trespassing incidents.
  - The effectiveness of institutional controls was presented in the *2004 Site Wide Institutional Controls Annual Assessment Report for Hanford CERCLA Response Actions* (DOE/RL-2004-56). The findings of this report indicate that institutional controls were maintained to prevent public access, as required.
- **RAO #3:** Provide information that will lead to a final remedy.
  - Since 1997, a significant mass of hexavalent chromium (719 kg) has been removed from groundwater underlying the 100-HR-3 OU; however, the overall areal extent of the 100-D Area hexavalent chromium plume has not been affected significantly by P&T operations. The new DX P&T system (2,300 L/min [600 gpm] as compared to 189.2 L/min [50 gpm] at the DR-5 system) will help facilitate remediation by expanding the capture zone, thereby drawing a larger volume of contaminated groundwater for treatment. In addition, drilling and installation of new characterization and monitoring wells has aided in defining the extent of contamination.

Preliminary RI results indicate that the conceptual site model for the 100-HR-3 OU remains the same. Most of the hexavalent chromium is already contained in the groundwater. Therefore, the interim remedy DX/HX systems will capture and treat residual hexavalent chromium.

  - Contaminant concentrations in aquifer tubes have been reduced.
  - Hexavalent chromium concentrations still exceed RAOs in compliance wells downgradient after ISRM has operated for multiple years. However, downgradient extraction wells for the DX P&T system were added to reduce hexavalent chromium concentrations before they can reach the Columbia River downgradient and upgradient of the ISRM barrier that will reduce concentrations to a level that is manageable by the ISRM barrier.

## 2.6 Recommendations

Recommendations for the 100-HR-3 OU are as follows:

- Understand operation of the newly designed and constructed DX/HX P&T systems. Extract and inject at the design rates and then vary the rates to understand the possible range of operation. Identify opportunities to optimize performance and operation of existing components for remediation at the DX P&T system (began operations at the end of CY 2010) and the HX P&T system (will begin operations in the fourth quarter of CY 2011).
- Evaluate the DX and HX systems to ensure that the zones of poor capture under HR-3 and DR-5 have been significantly reduced or eliminated, including the addition of selected pressure transducers and data loggers in the eastern 100-D Area.
- Update the groundwater model with actual well flow rates and P&T system data from the DX system startup late in CY 2010 for future analysis.
- Revise the remedial design/remedial action work plan to reflect upgrades to the DX and HX P&T systems, and obtain concurrence from Ecology on the associated monitoring well network and analyte list.
- Initiate installation of a compliance well network for the DX and HX P&T systems consisting of approximately 11 additional monitoring wells located primarily along the 100-D and 100-H Area shorelines for river protection monitoring plus several interior to the plume for groundwater cleanup monitoring. Include these wells in future sampling events.
- Initiate pumping at the DX system in CY 2011 from the 100-D Area hot spot using wells 199-D5-99 and 199-D5-122 to remove the highest concentrations of hexavalent chromium in the River Corridor and investigate continuing source issues.
- Incorporate the results of RI/FS sampling into the interim remedial actions and monitoring as necessary.
- Continue to investigate the potential for a separate chromium source in the northern 100-D Area incorporating new RI/FS wells, including additional monitoring frequency in selected areas and new monitoring wells if necessary.
- Integrate field observations made during remediation of “high-priority chromium sites” with groundwater monitoring. Install additional wells or change monitoring frequency to monitor remediation impacts to groundwater.

Additional recommendations include the following:

- Evaluate the response of the 100-D Area hot spot to pumping of the larger volumes in the DX system.
- Evaluate the response of the 100-D Area hot spot to the 100-D-100 excavation of the overlying vadose zone sediments in the adjacent monitoring wells.
- Continue to pump the contaminated zone in the RUM in the 100-H Area after startup of the HX P&T system. Consider adding wells to the network based on the refined nature and extent developed in the 100-D and 100-H Area RI/FS. Until startup, monitor for potential concentration rebounds in groundwater within the zone of influence of the HR-3 system.

- The timing of P&T system shutdowns will be planned to minimize contaminant flux to the Columbia River by scheduling outages during high river stage times of the year (i.e., spring and summer).
- Evaluate concentration changes in the 100-H Area during the transition from the HR-3 system to the HX system in CY 2011 while the pumps are shut down to determine whether concentration rebound is occurring.
- Evaluate the effectiveness of the new DX and HX P&T systems with respect to the 2012 Tri-Party Agreement Milestone M-016-110-TO1 target using groundwater concentration data, hydraulic head data, capture zone analyses, and further modeling to integrate the model with the data.
- Continue to review and modify the groundwater cleanup strategy for interim actions and evaluate alternatives.

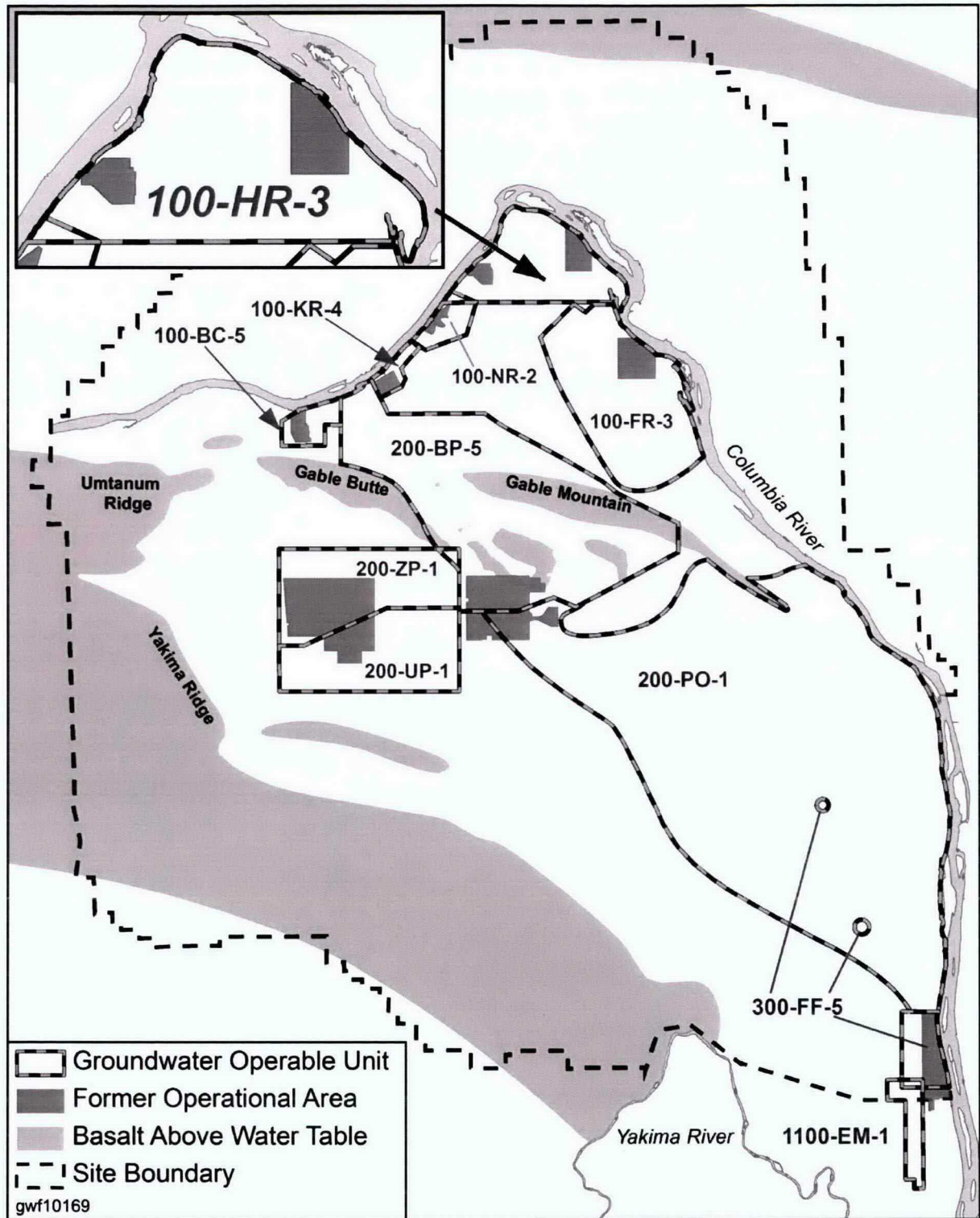


Figure 2-1. Location Map of the 100-HR-3 OU

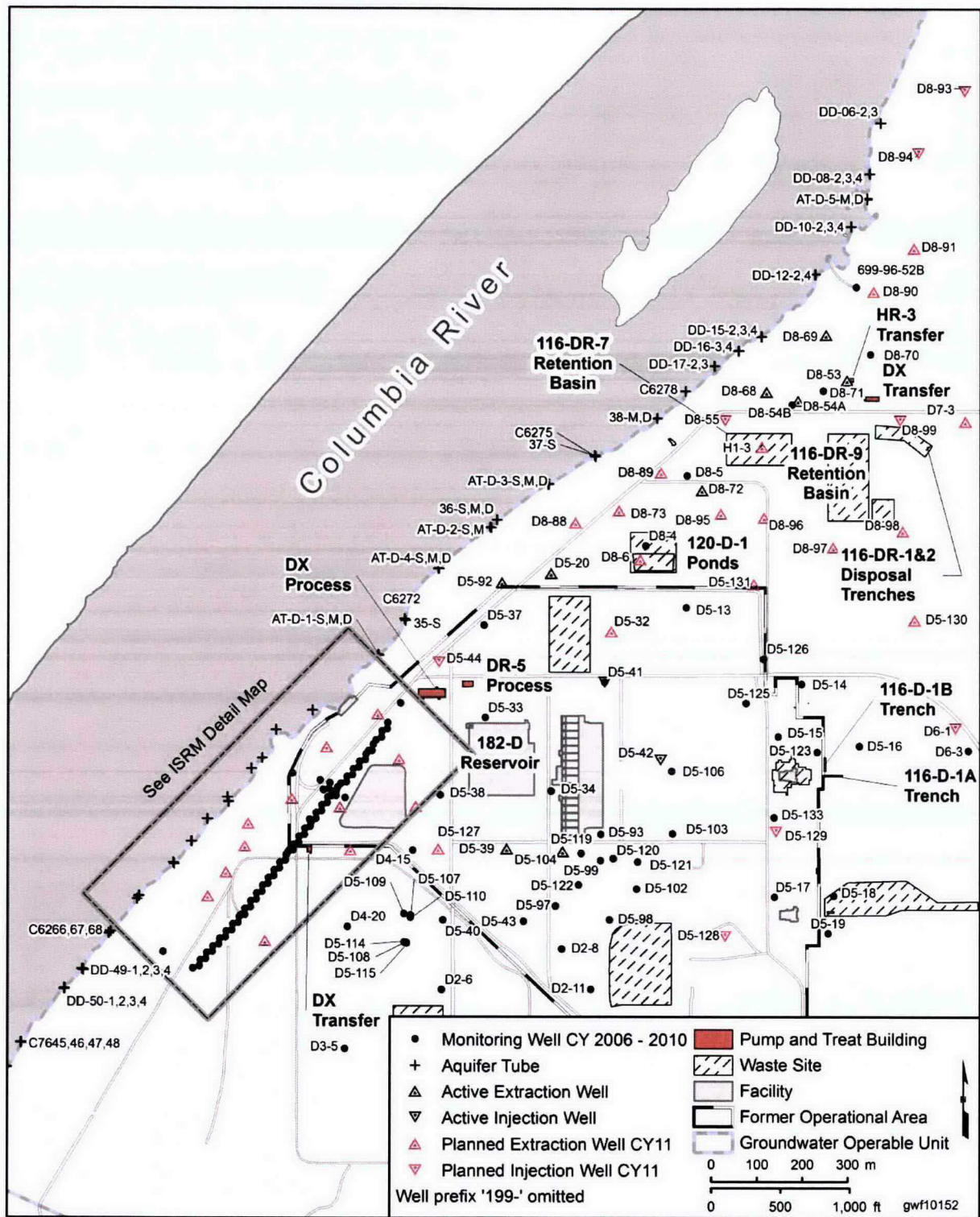
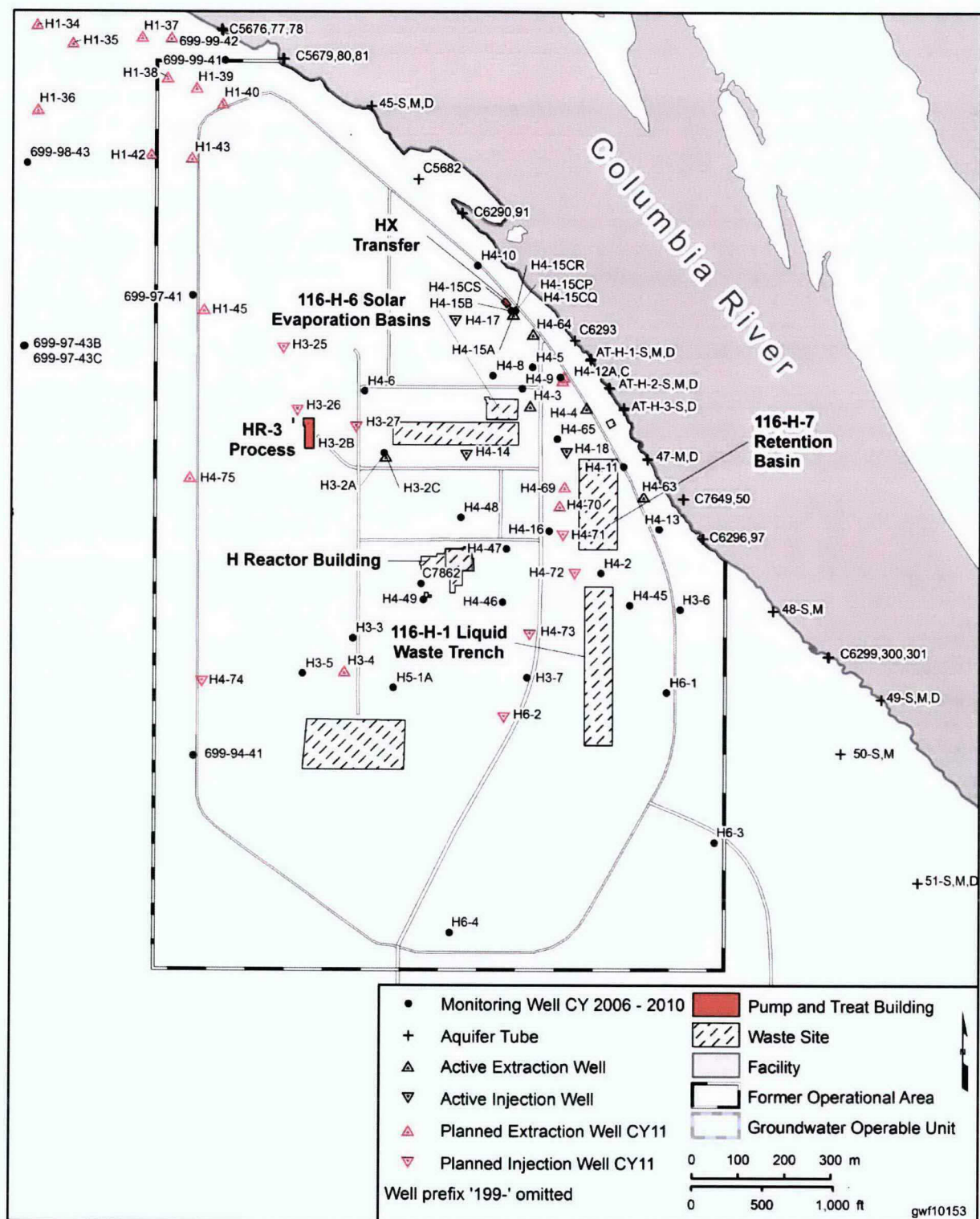


Figure 2-2. 100-D Area Wells and Aquifer Tubes



**Figure 2-3. 100-H Area Wells and Aquifer Tubes**

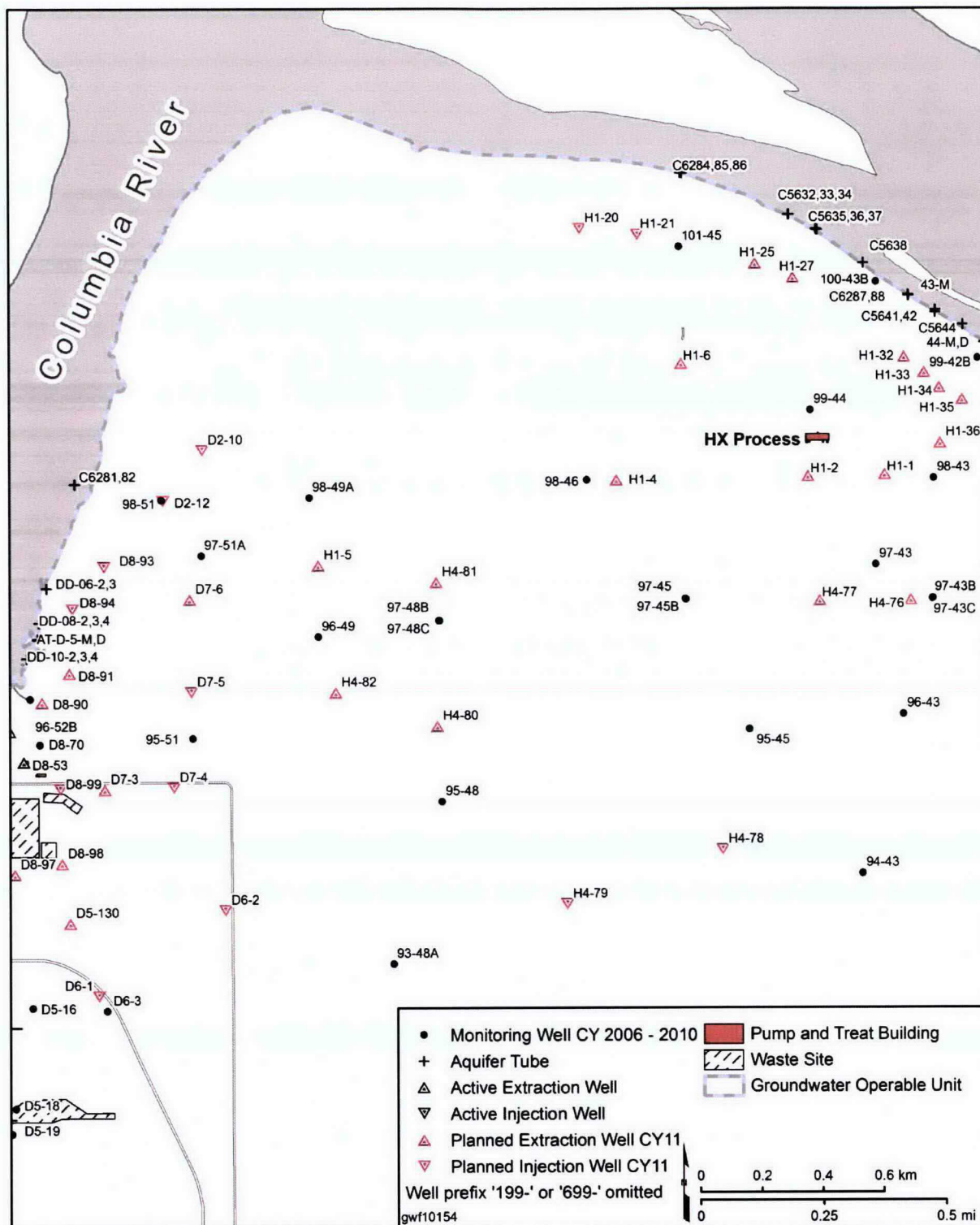


Figure 2-4. Monitoring Well Locations Within the Horn Area of the 100-HR-3 OU

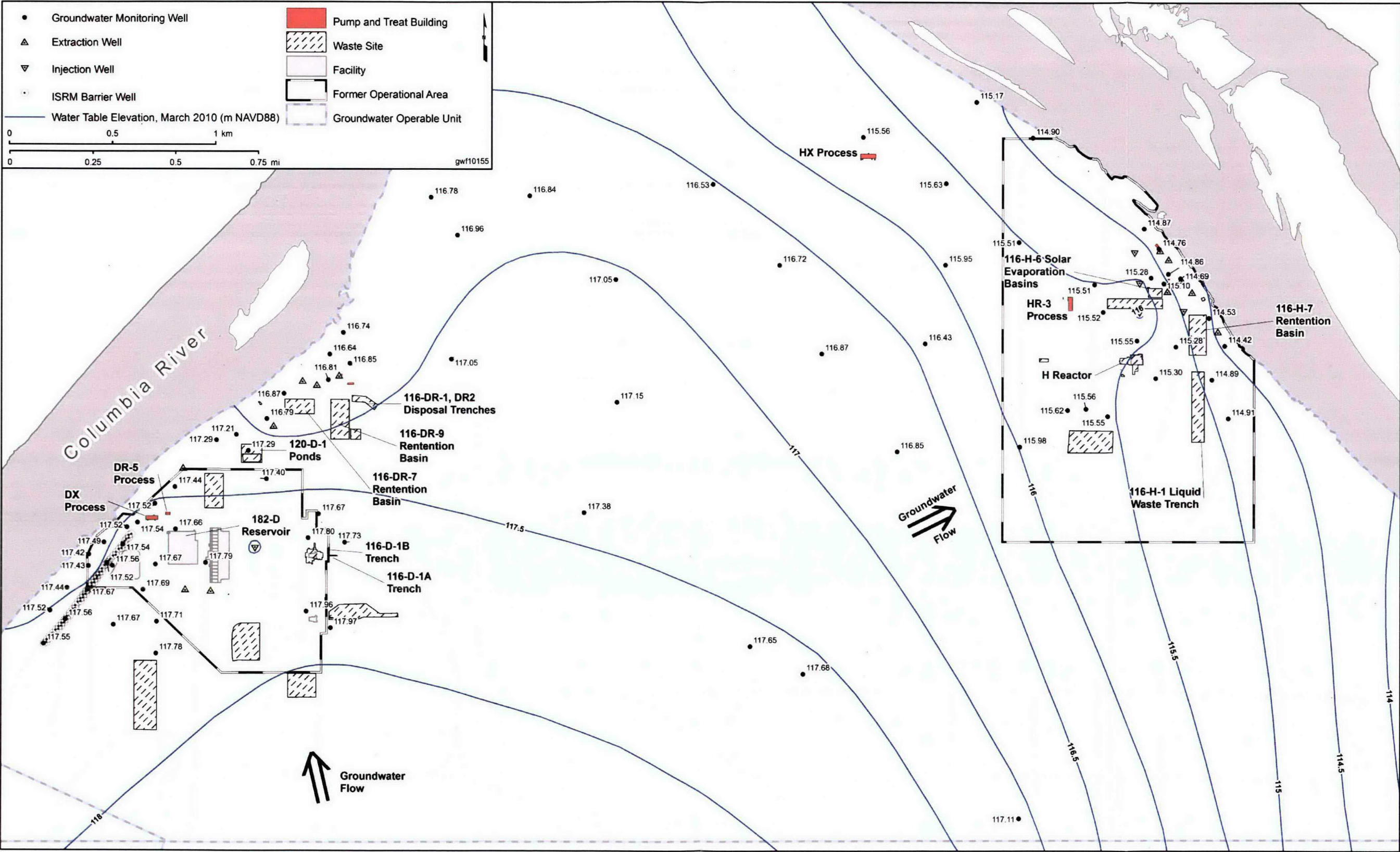


Figure 2-5. 100-HR-3 OU Water Table Elevation Map, March 2010

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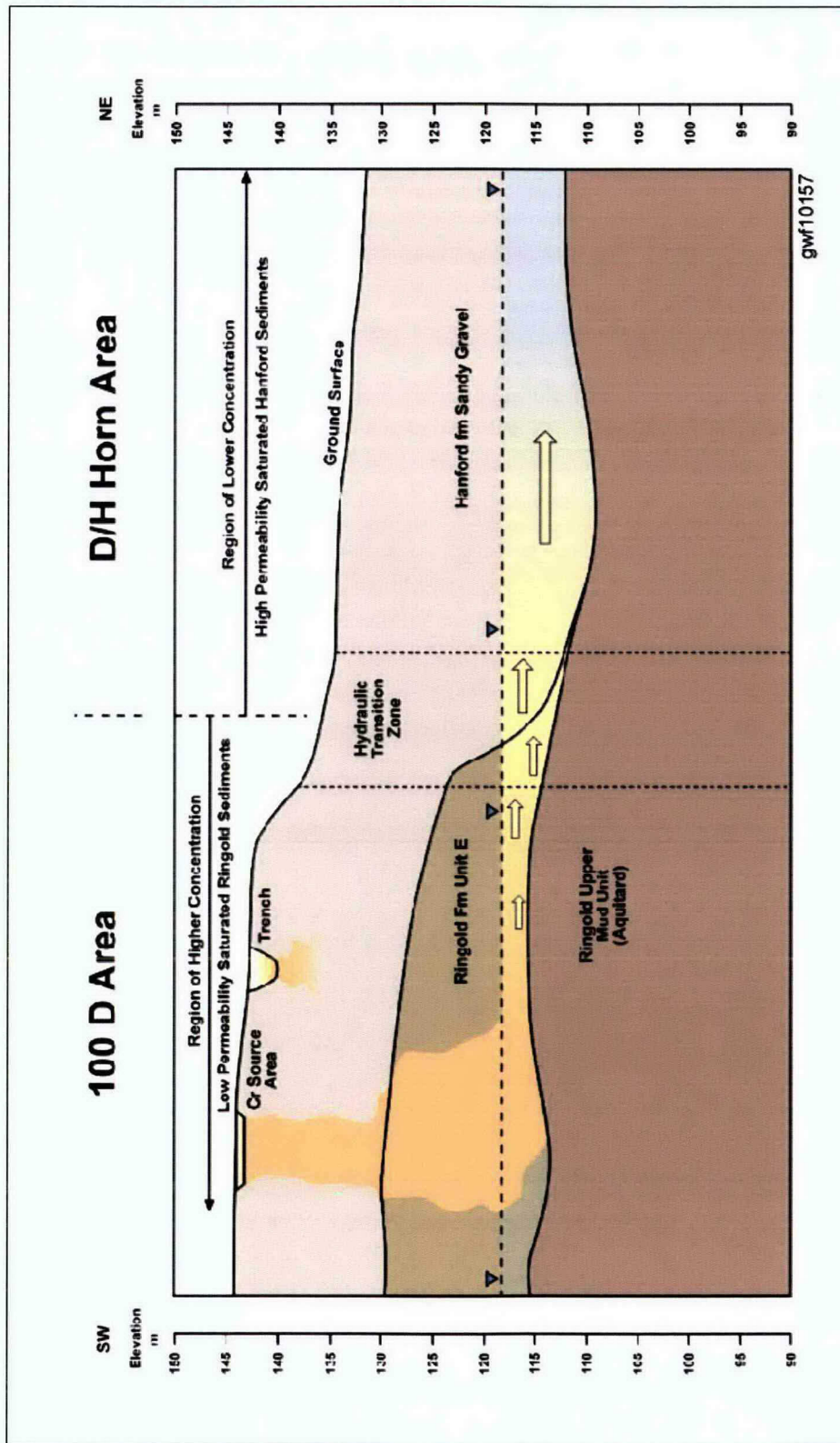


Figure 2-6. Conceptual Cross Section of the 100-D and 100-H Areas

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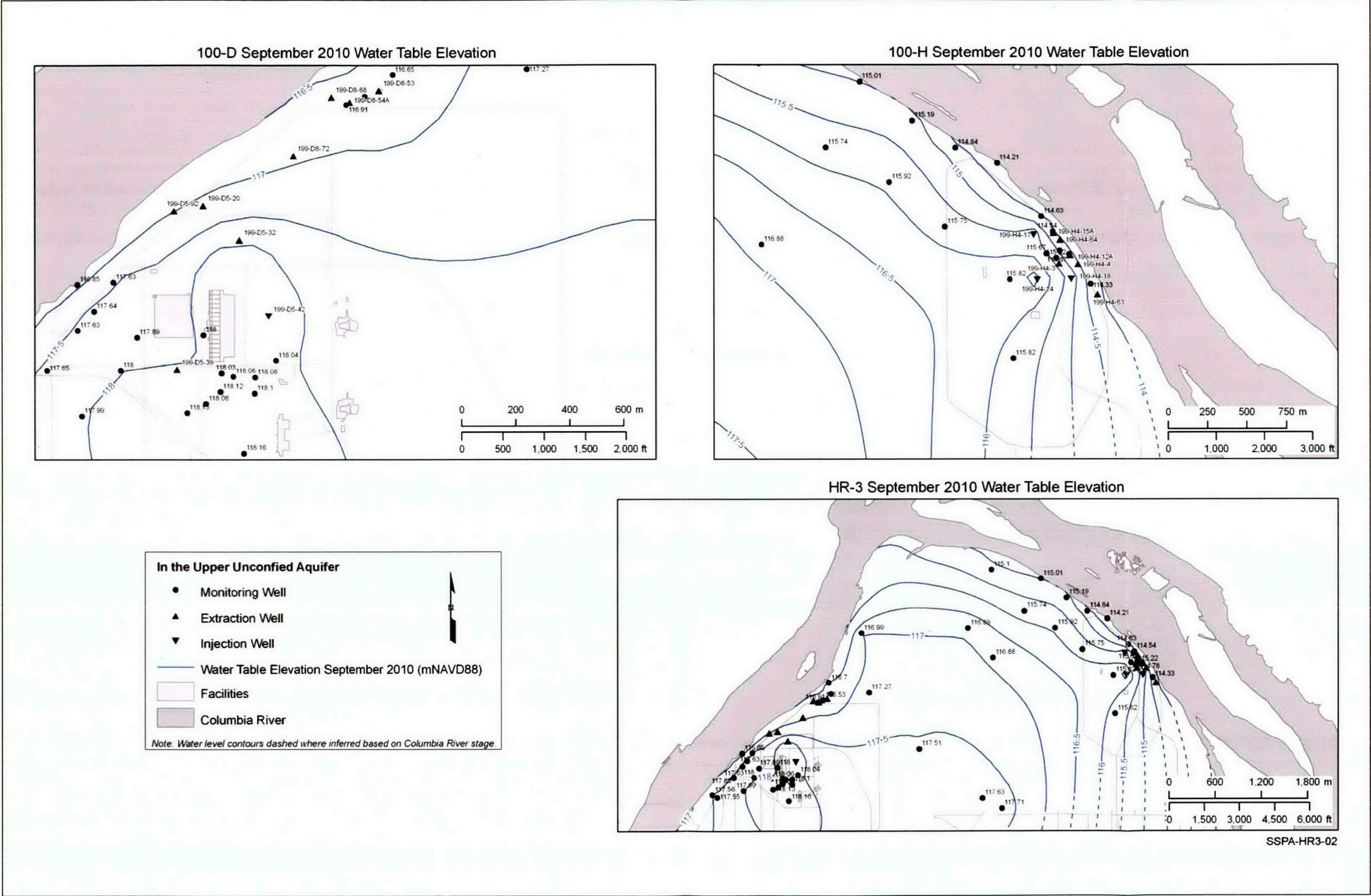


Figure 2-7. 100-HR-3 OU Water Table Elevation Map, September 2010

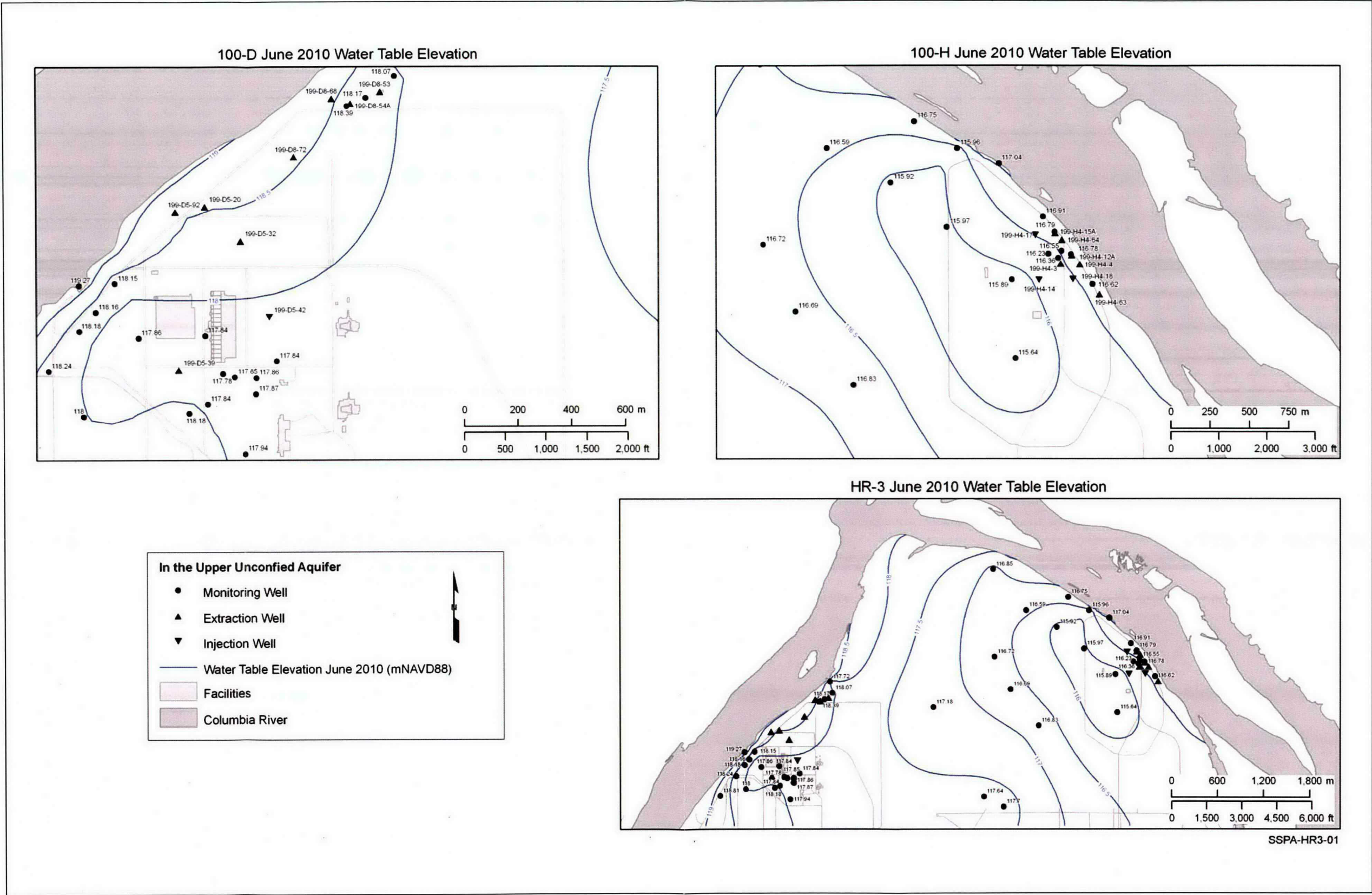


Figure 2-8. 100-HR-3 OU Water Table Elevation Map, June 2010

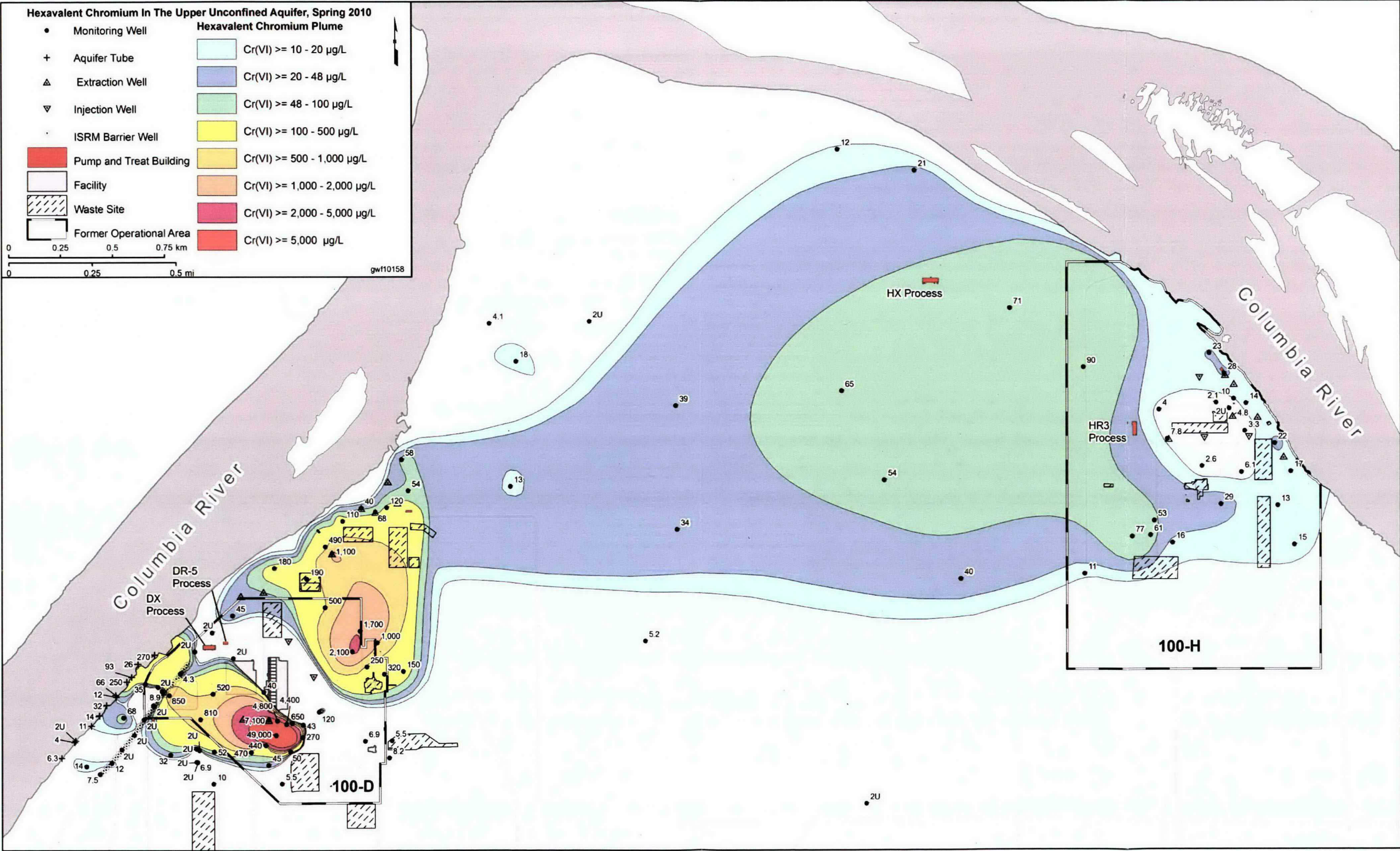


Figure 2-9. 100-HR-3 OU Hexavalent Chromium Map, Spring 2010

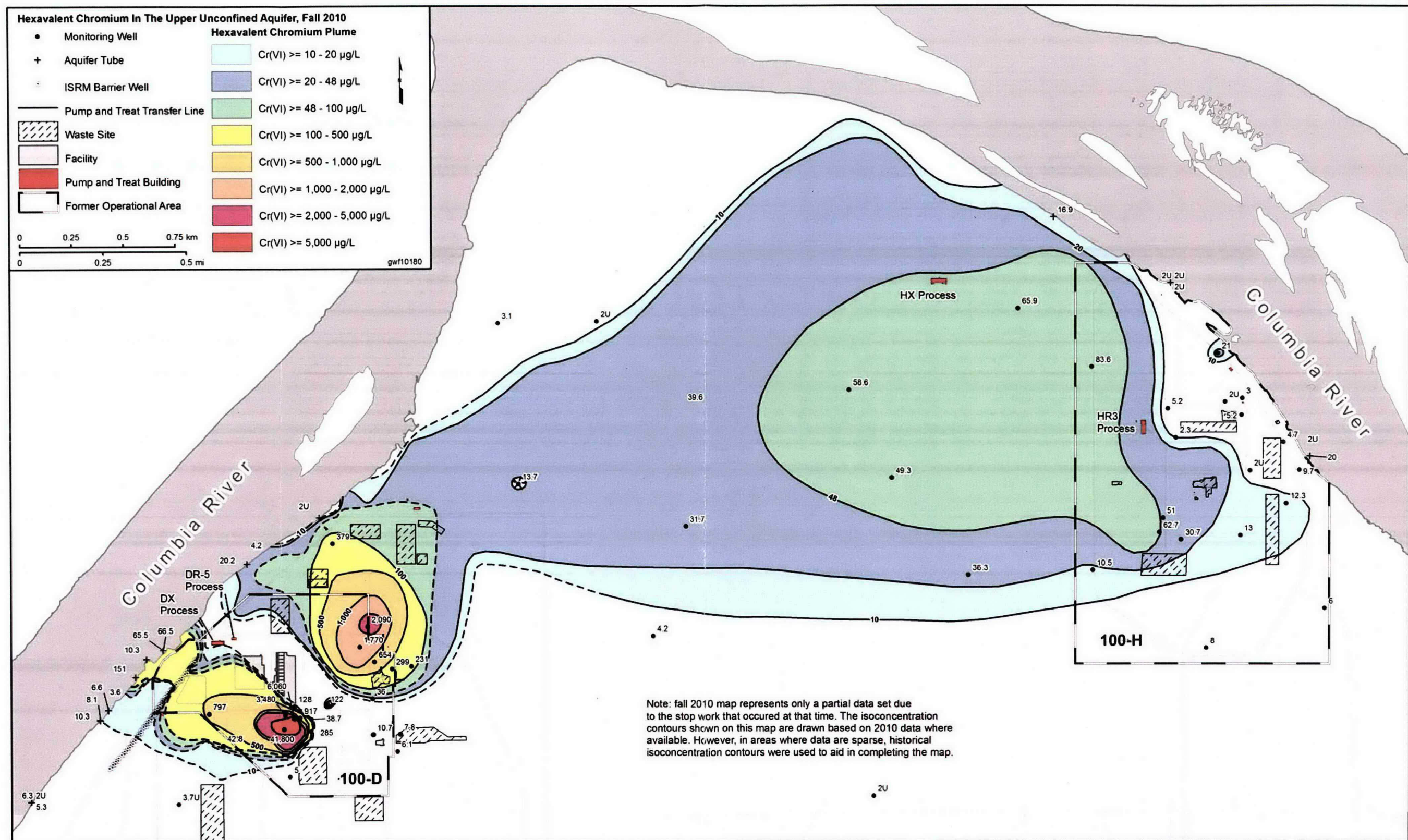


Figure 2-10. 100-HR-3 OU Hexavalent Chromium Map, Fall 2010

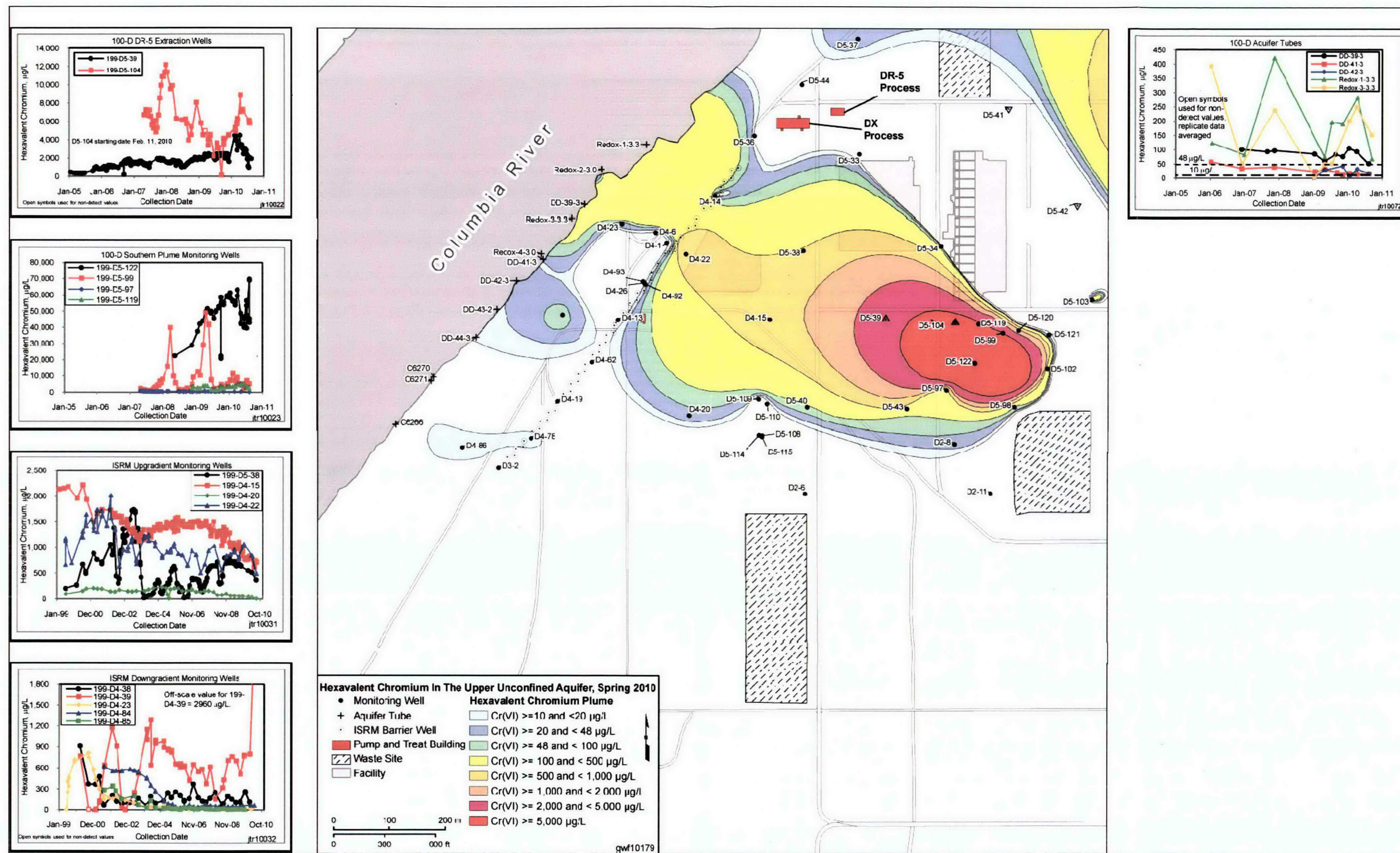


Figure 2-11. 100-D Area Hexavalent Chromium Spring 2010 Plume with Trend Plots (South Plume)

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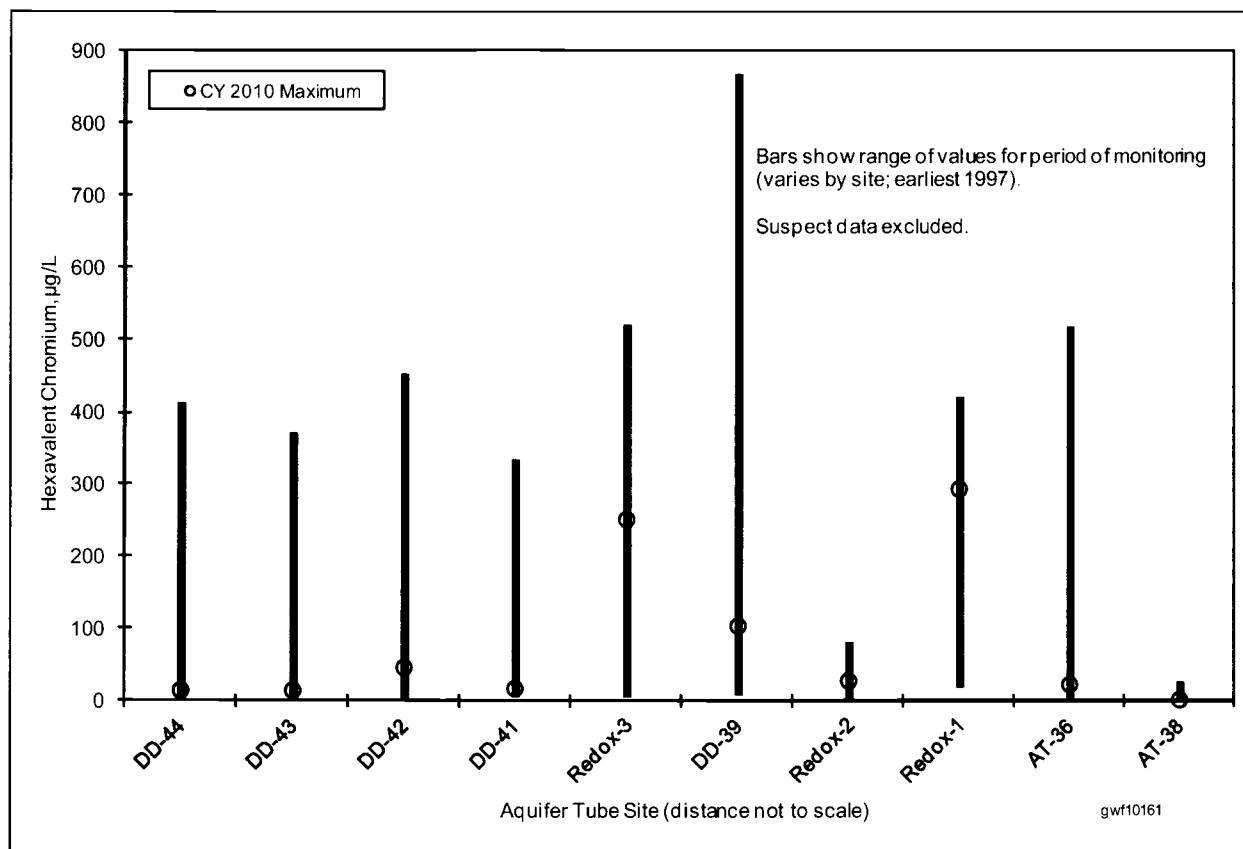
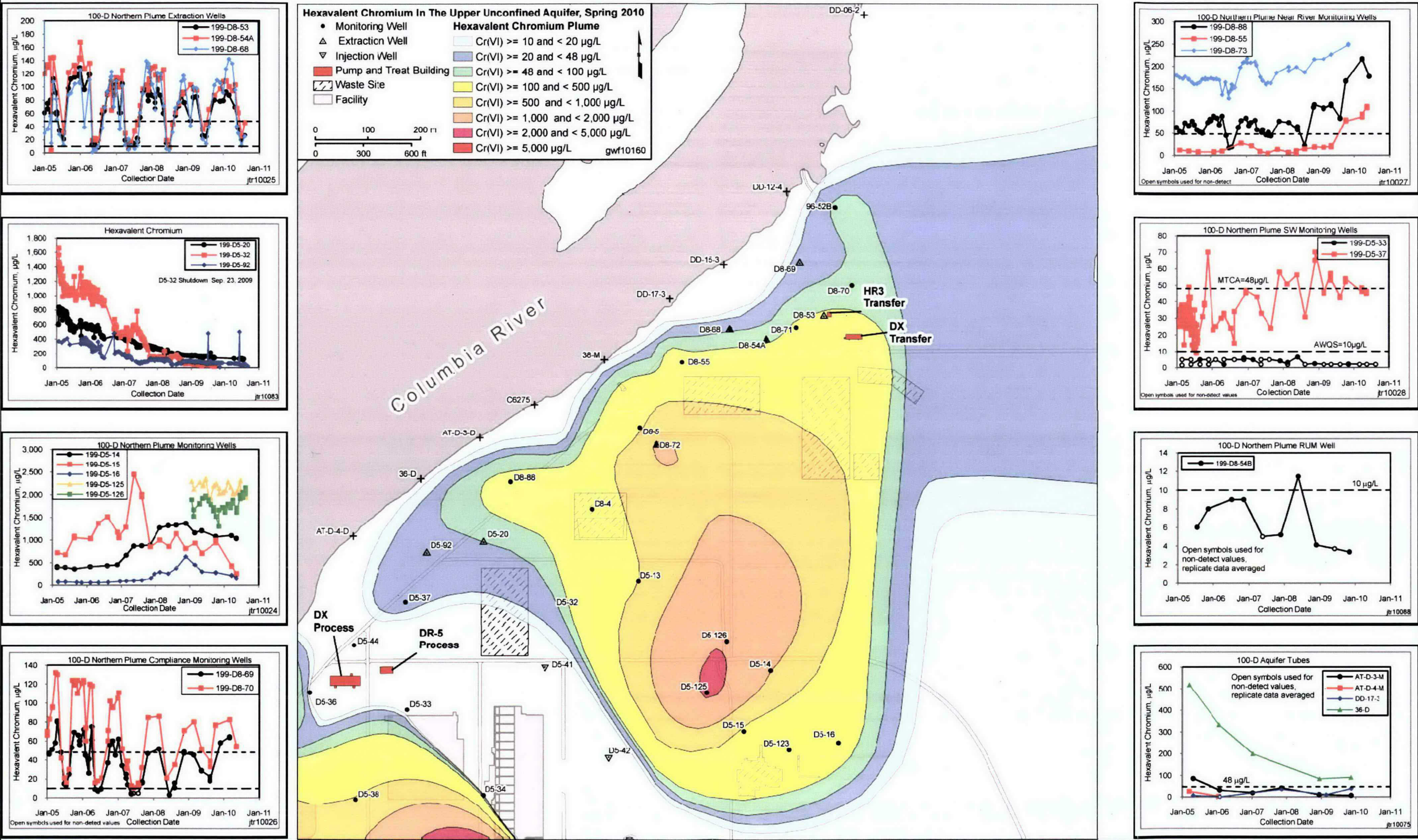


Figure 2-12. 100-D Area Aquifer Tubes

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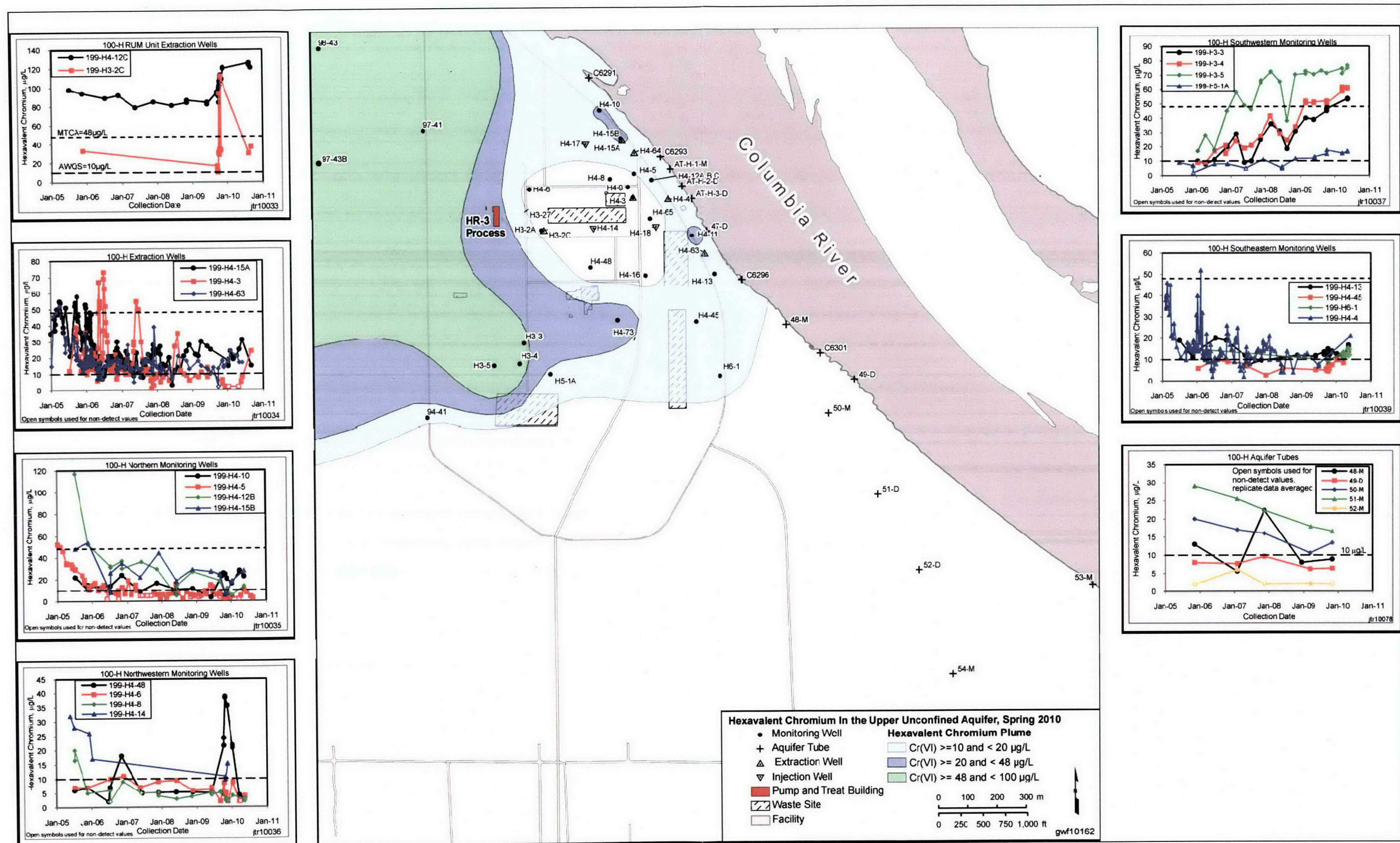


Figure 2-14. 100-H Area Hexavalent Chromium Spring 2010 Plume Trend Plots

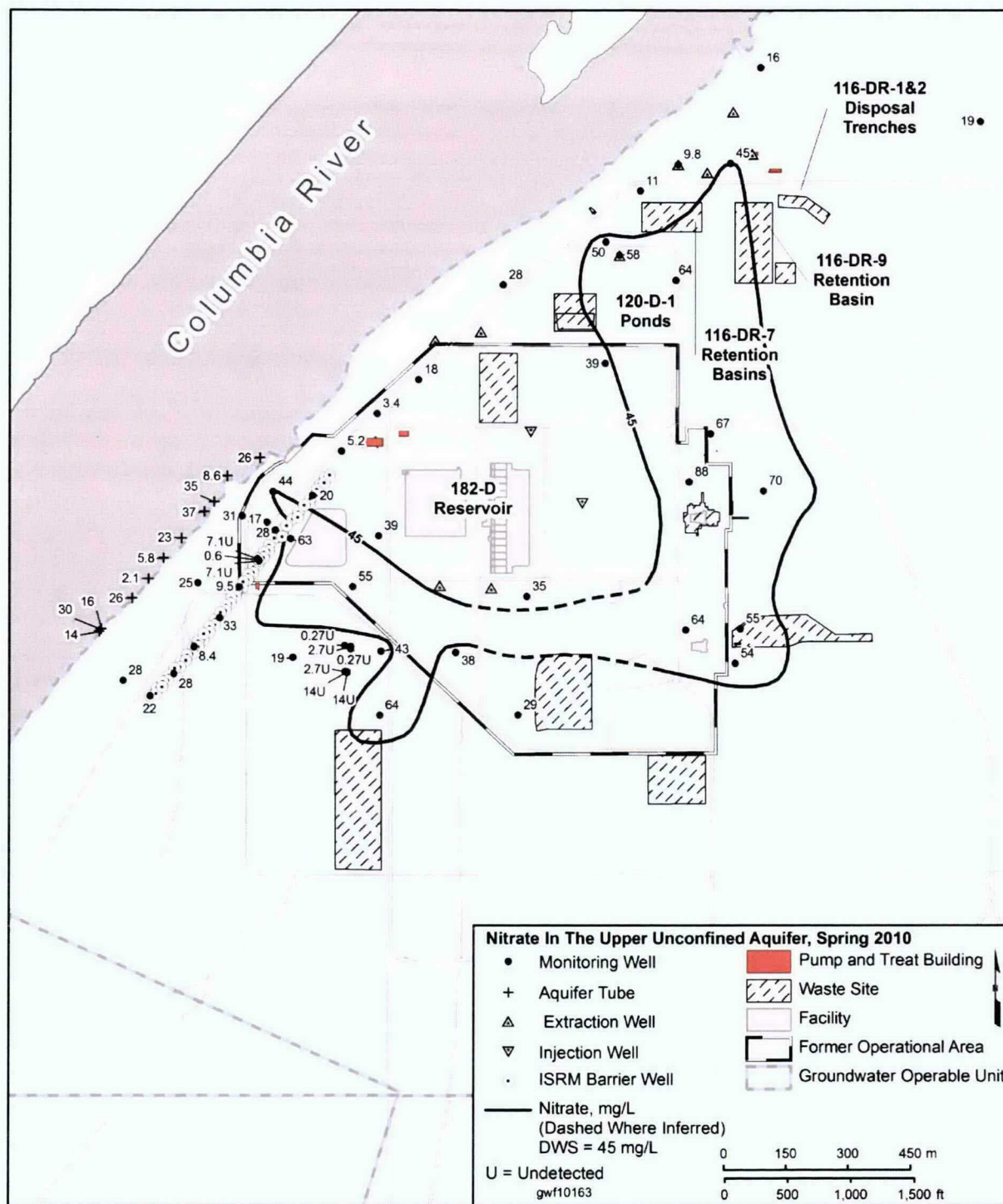


Figure 2-15. Nitrate in the 100-D Area

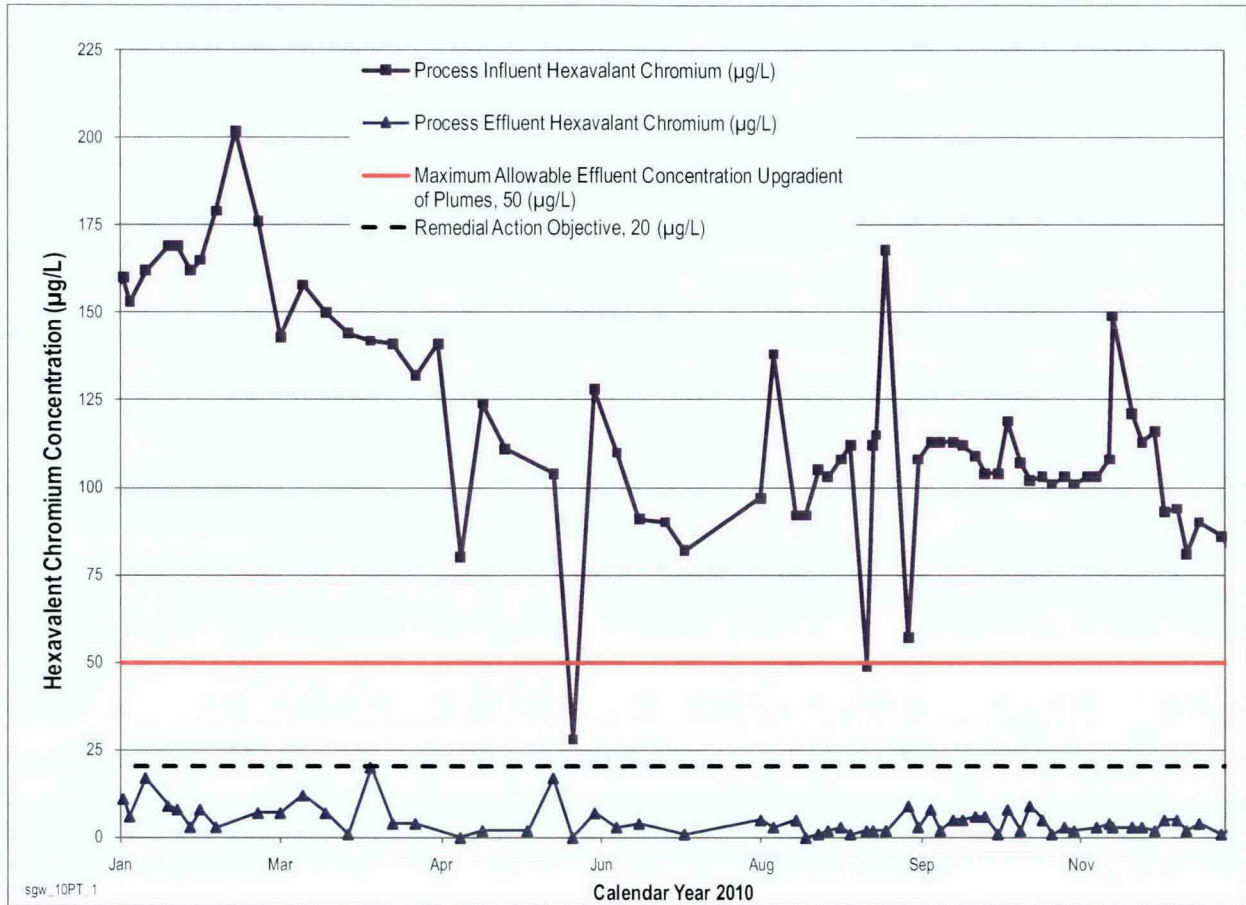


Figure 2-16. Influent/Effluent Concentrations and Removal Efficiencies for 100-HR-3 P&T System

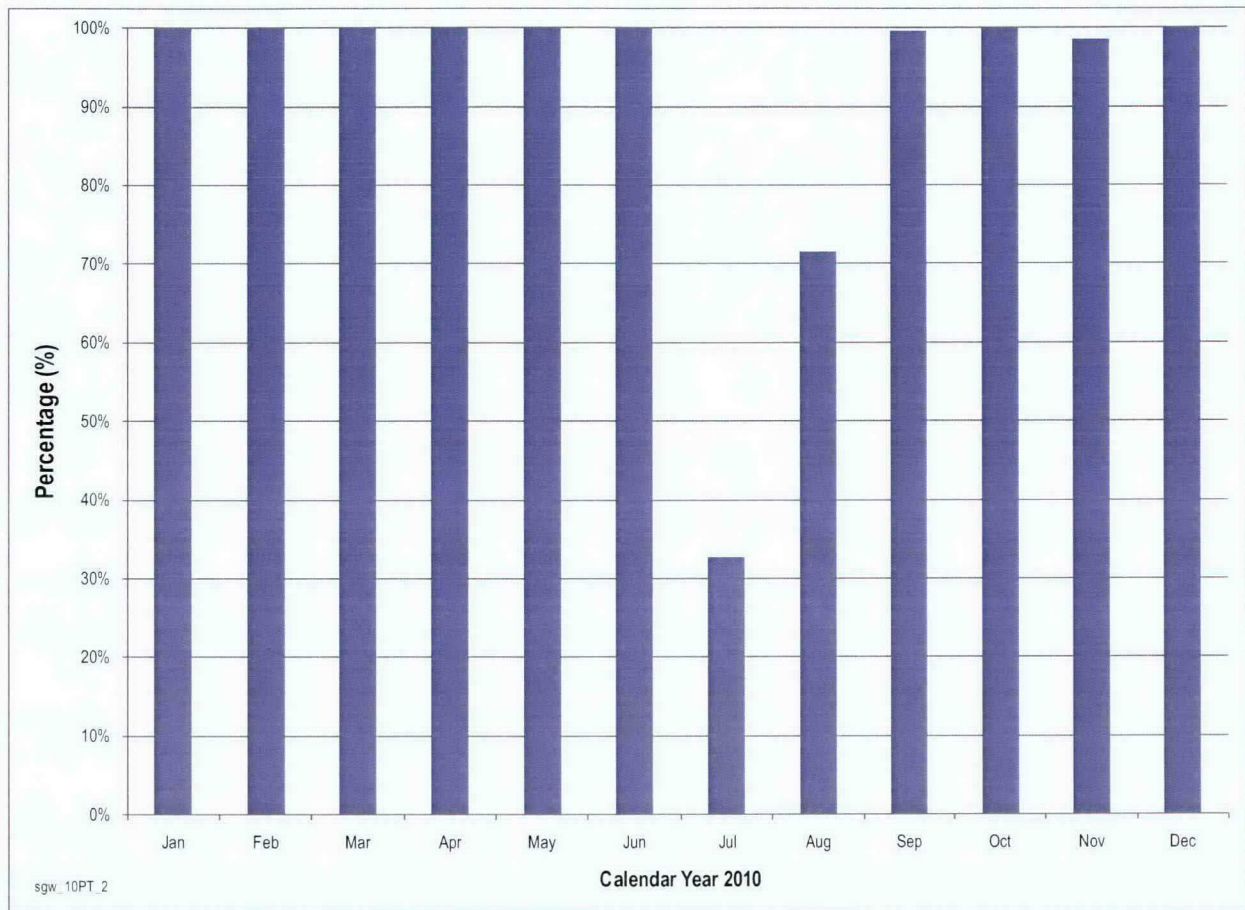


Figure 2-17. System Availability for 100-HR-3 P&T System

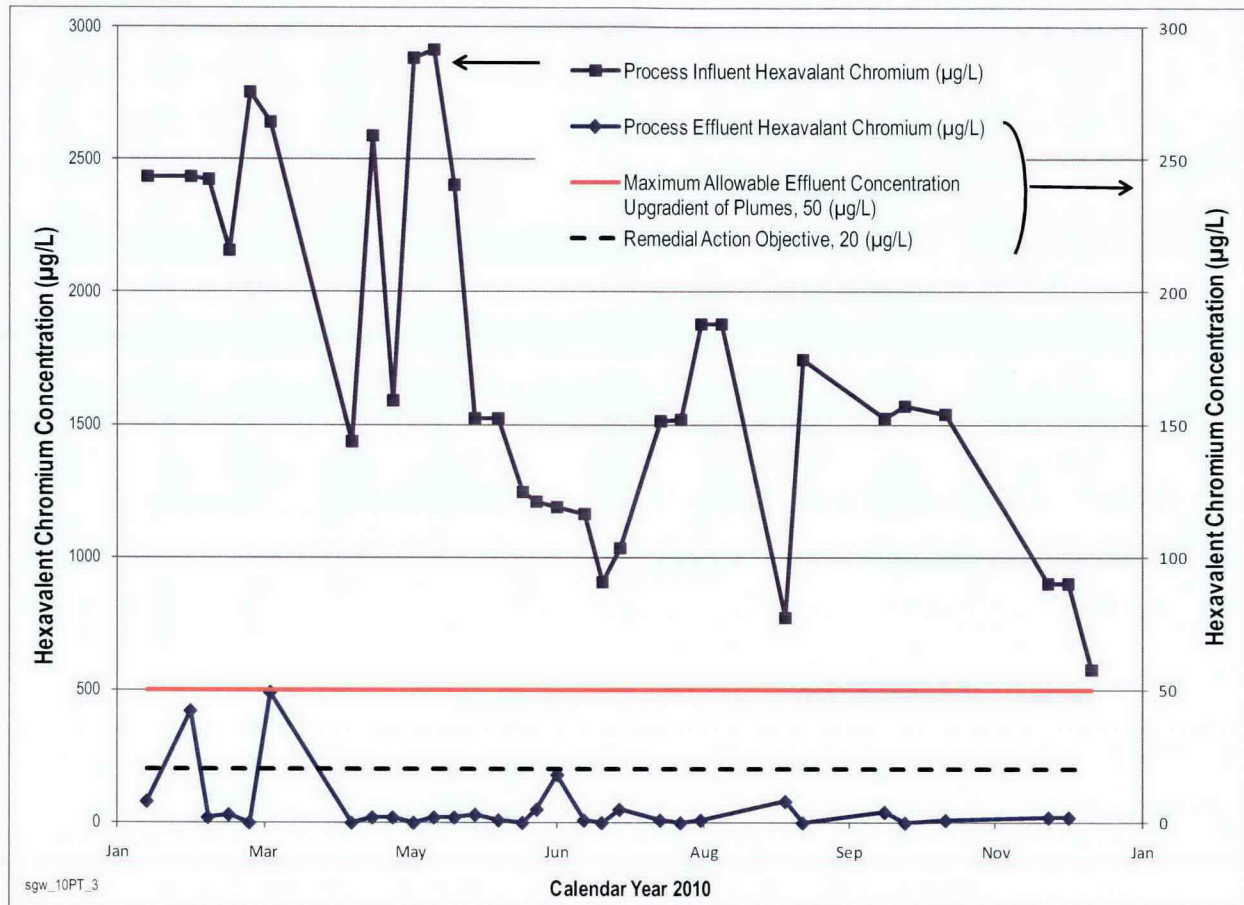


Figure 2-18. Influent/Effluent Concentrations and Removal Efficiencies for DR-5 P&T System

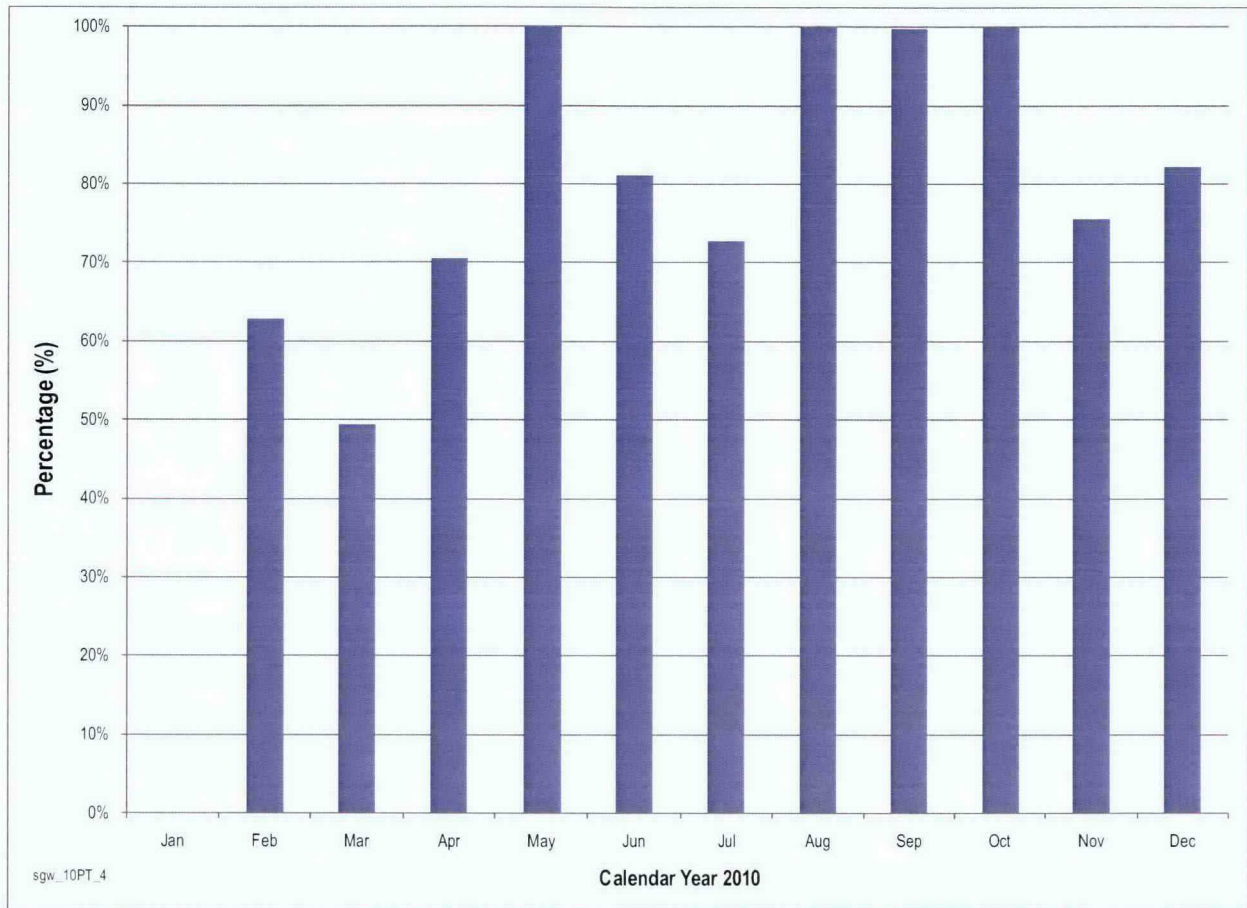


Figure 2-19. System Availability for DR-5 P&T System

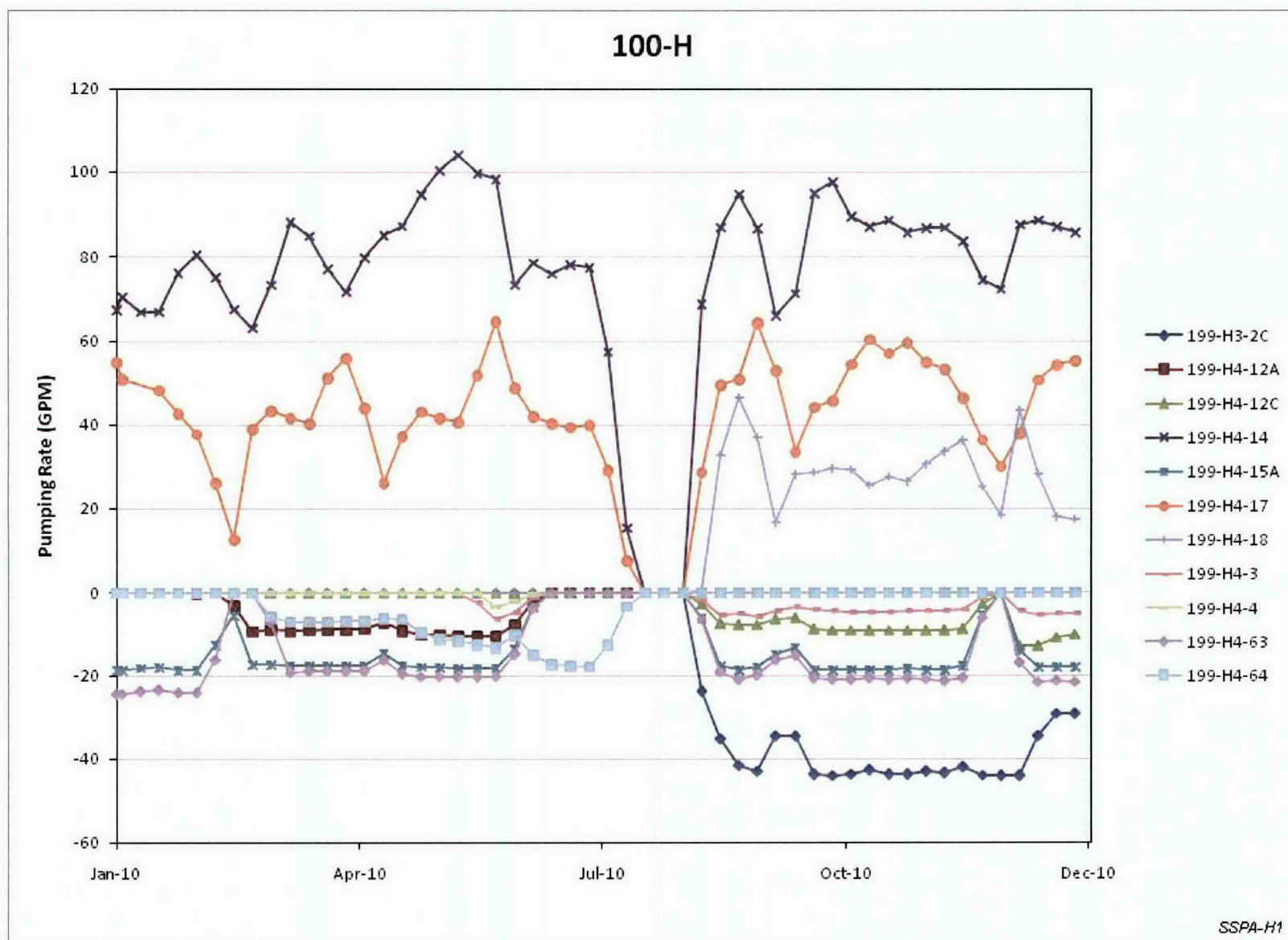


Figure 2-20. Pumping Rates for 100-H Area Treatment System

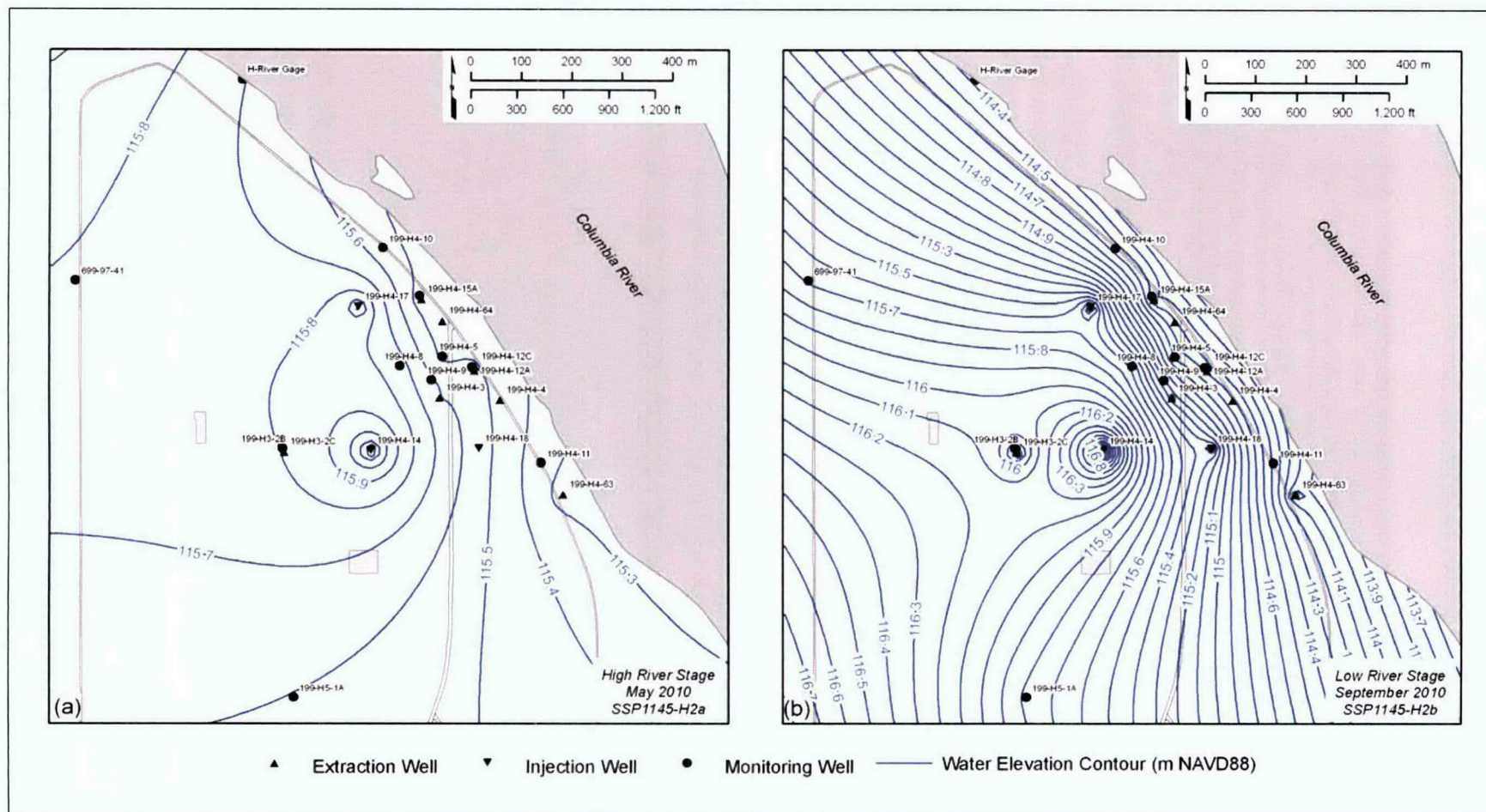


Figure 2-21. Example Groundwater Elevation Contours Throughout the 100-H Area for (a) High River-Stage Conditions (Week of May 30, 2010) and (b) Low River-Stage Conditions (Week of September 26, 2010)

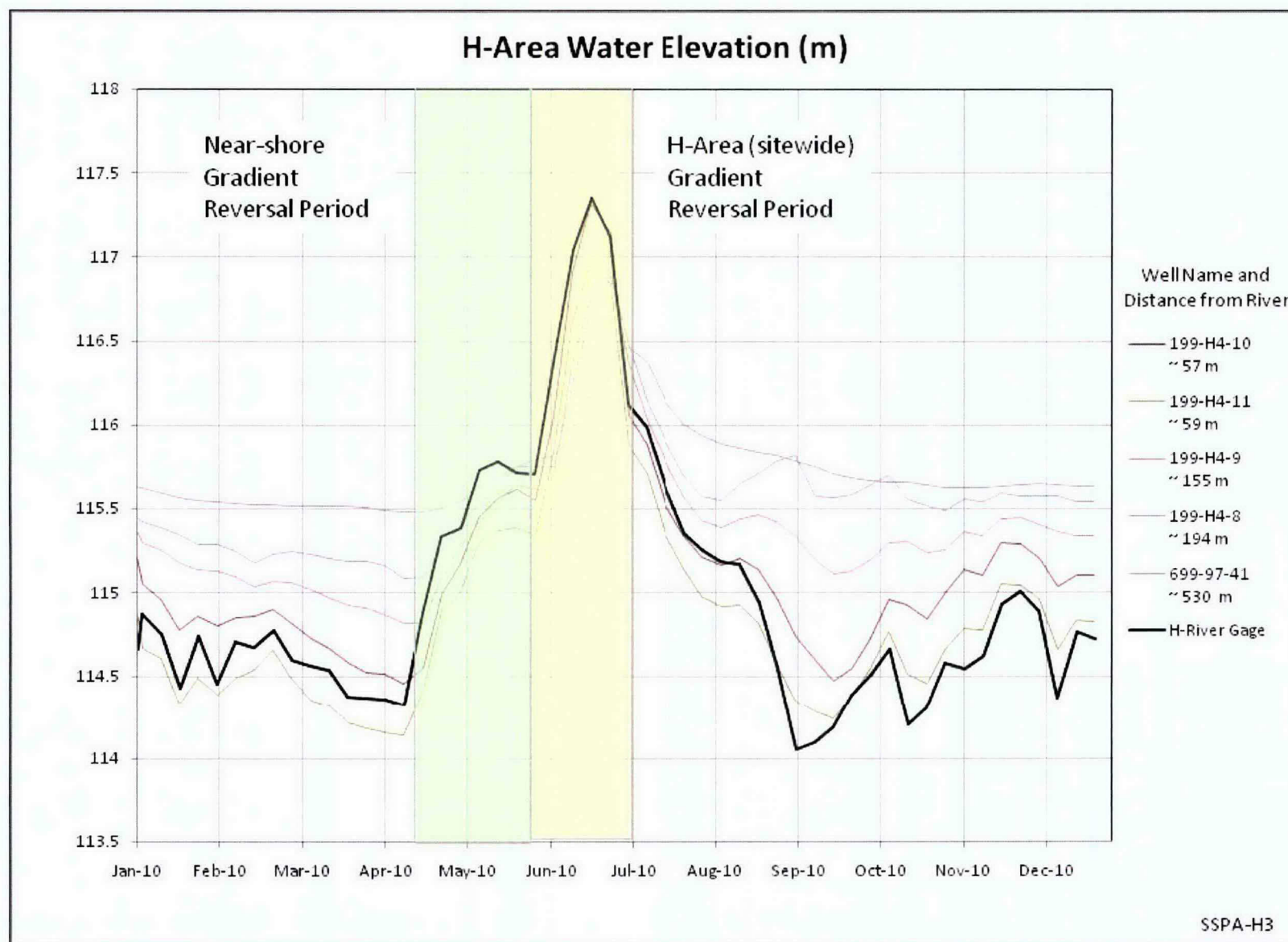


Figure 2-22. Hydrographs for Selected 100-H Area Monitoring Wells with River Stage

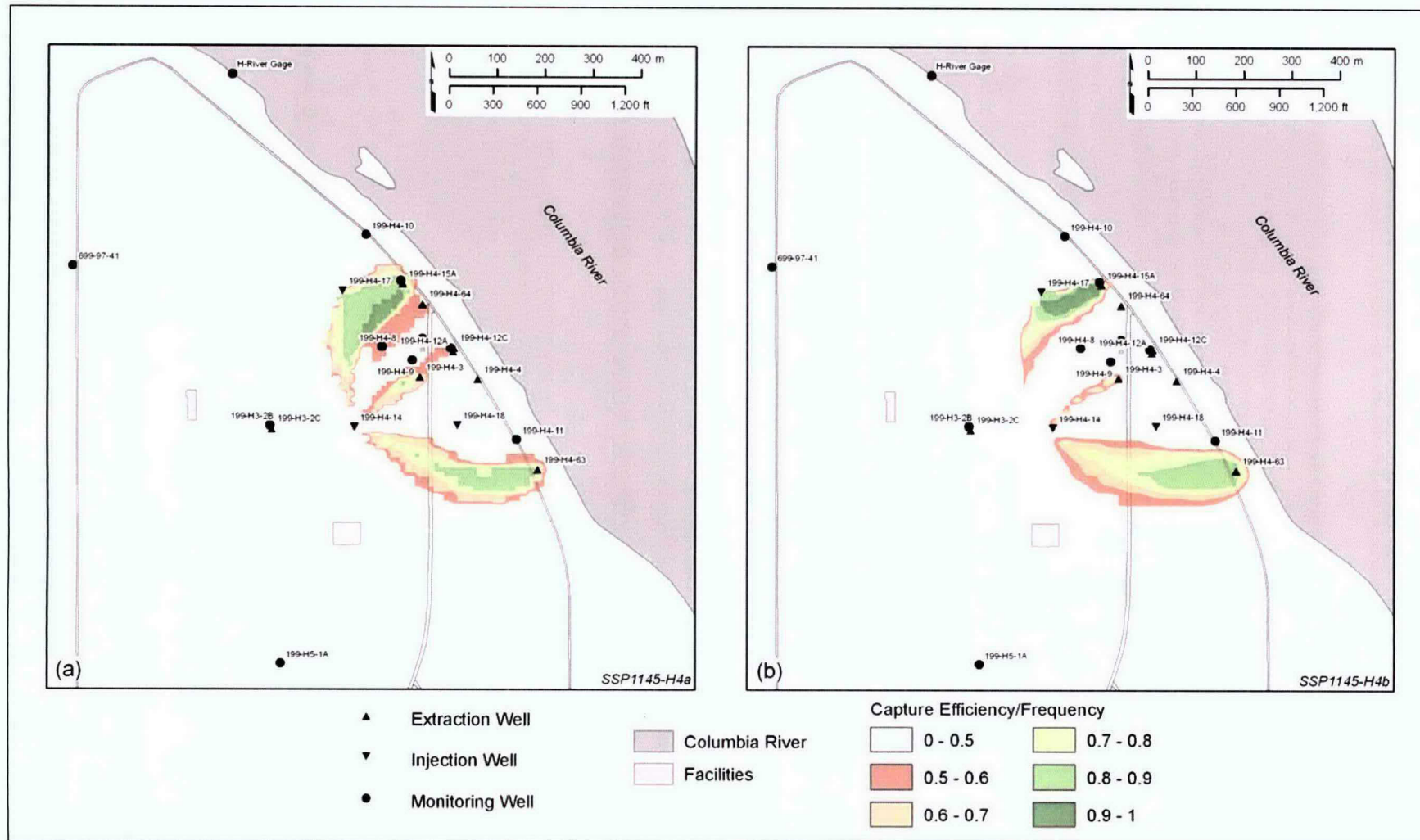


Figure 2-23. Approximate Extent of Capture Throughout the 100-H Area for January to October 2010, Calculated Using (a) Modeling Method and (b) Mapping Method

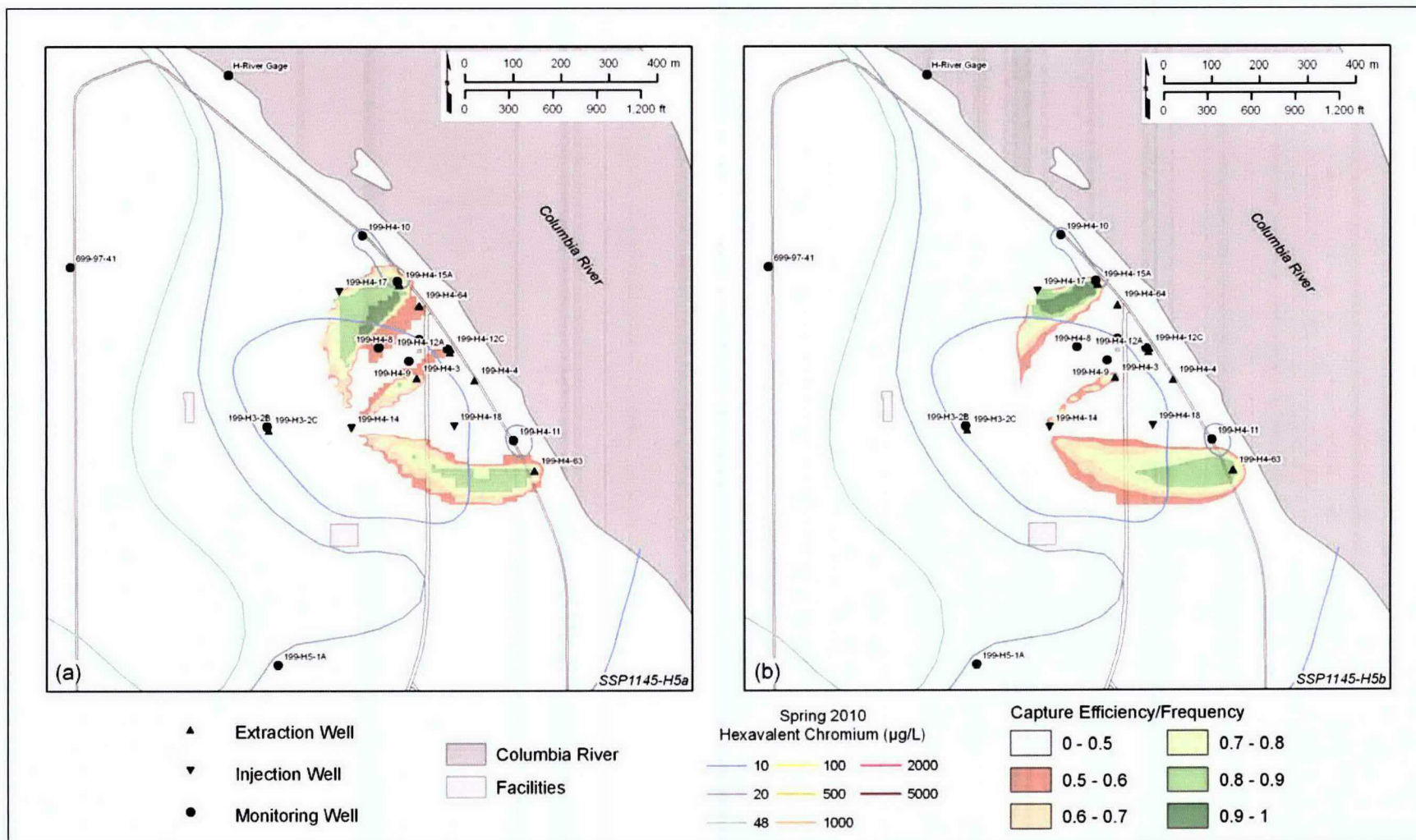


Figure 2-24. Approximate Extent of Capture Throughout the 100-H Area for January to October 2010, Calculated Using (a) Modeling Method and (b) Mapping Method (Overlaid with Spring 2010 Contoured Extent of Hexavalent Chromium)

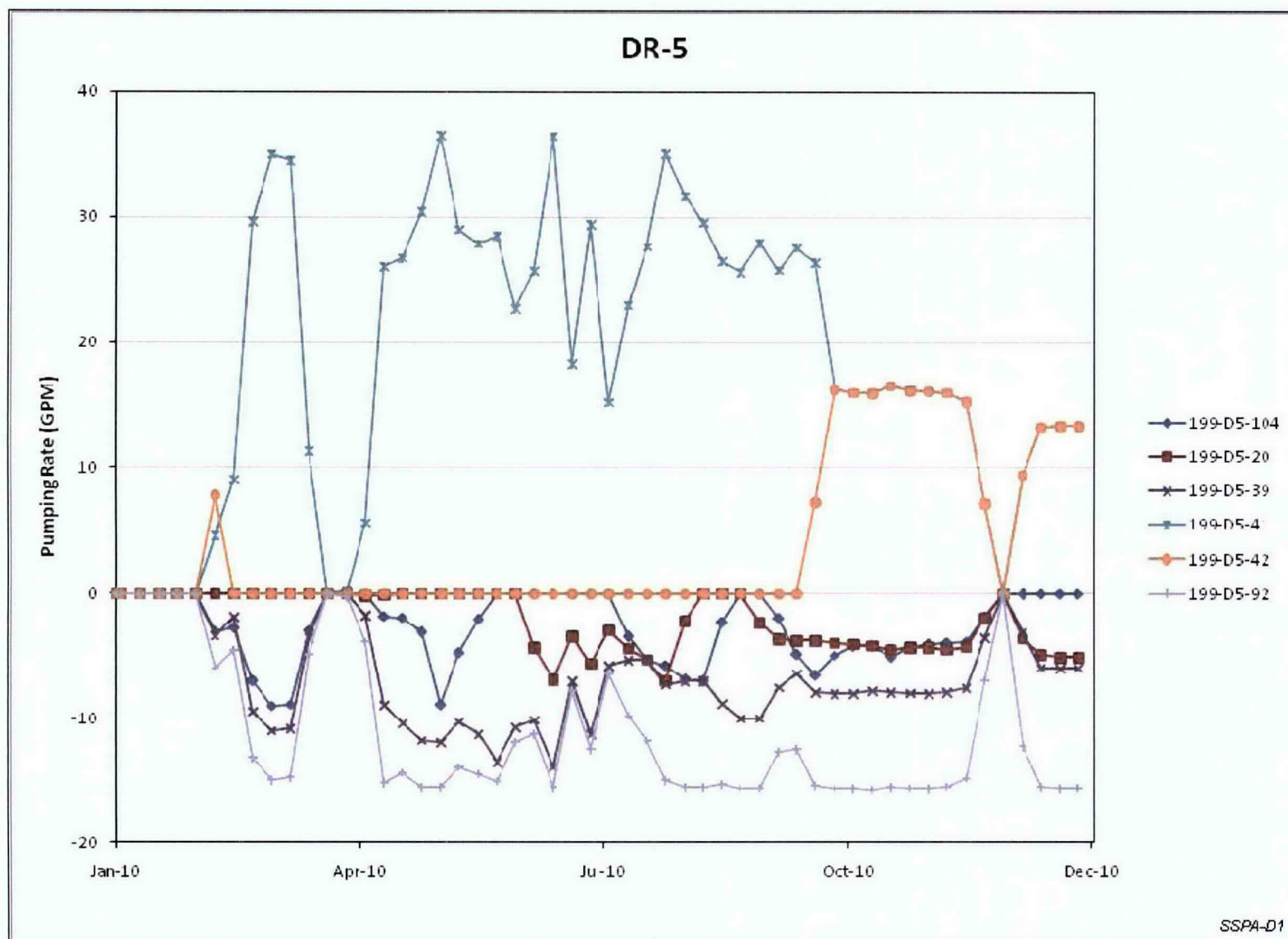


Figure 2-25. Pumping Rates for D5 P&amp;T System Wells

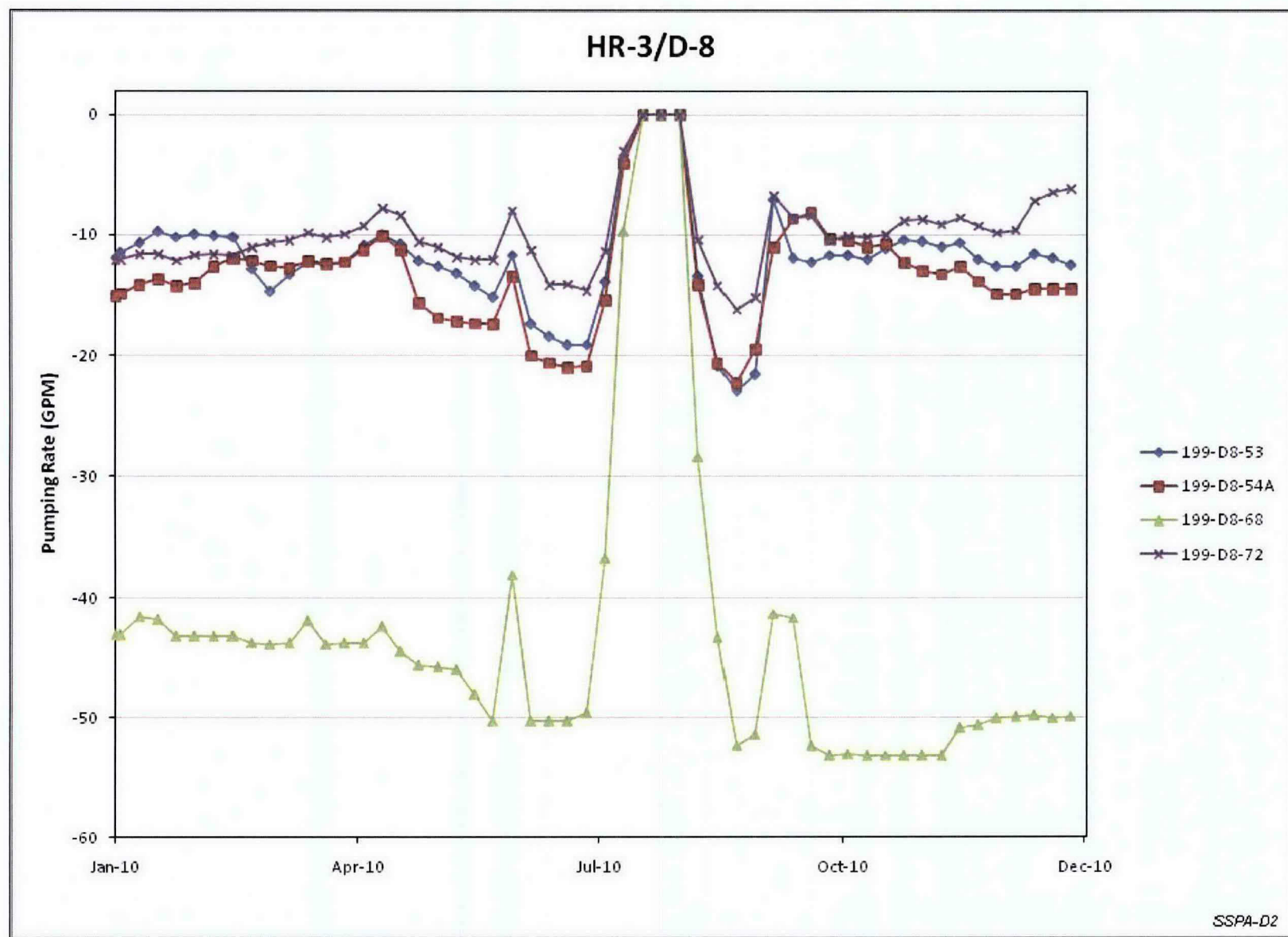


Figure 2-26. Pumping Rates for D8 P&amp;T System Wells

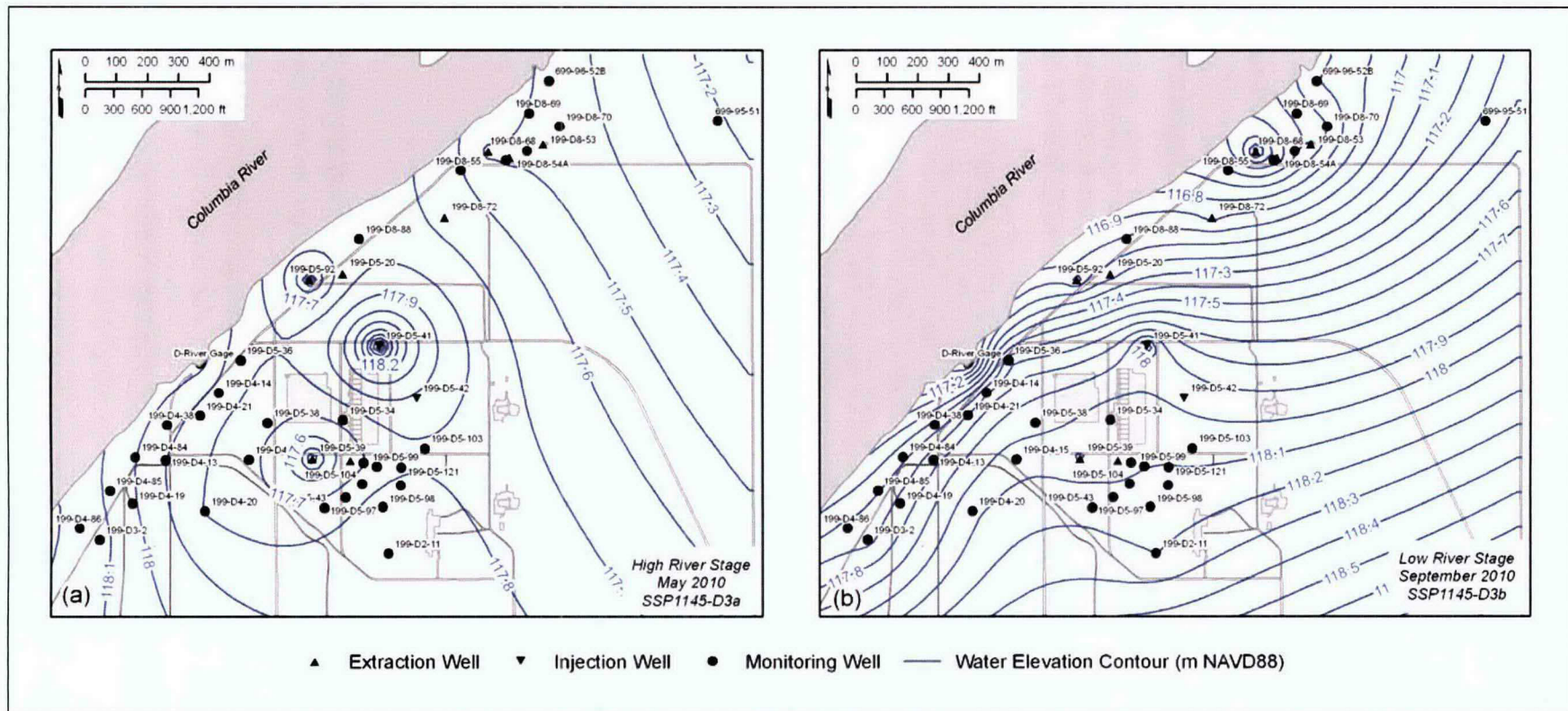


Figure 2-27. Example Groundwater Elevation Contours Throughout the 100-D Area for (a) High River Stage (Week of May 23, 2010) and (b) Low River-Stage Conditions (Week of September 5, 2010)

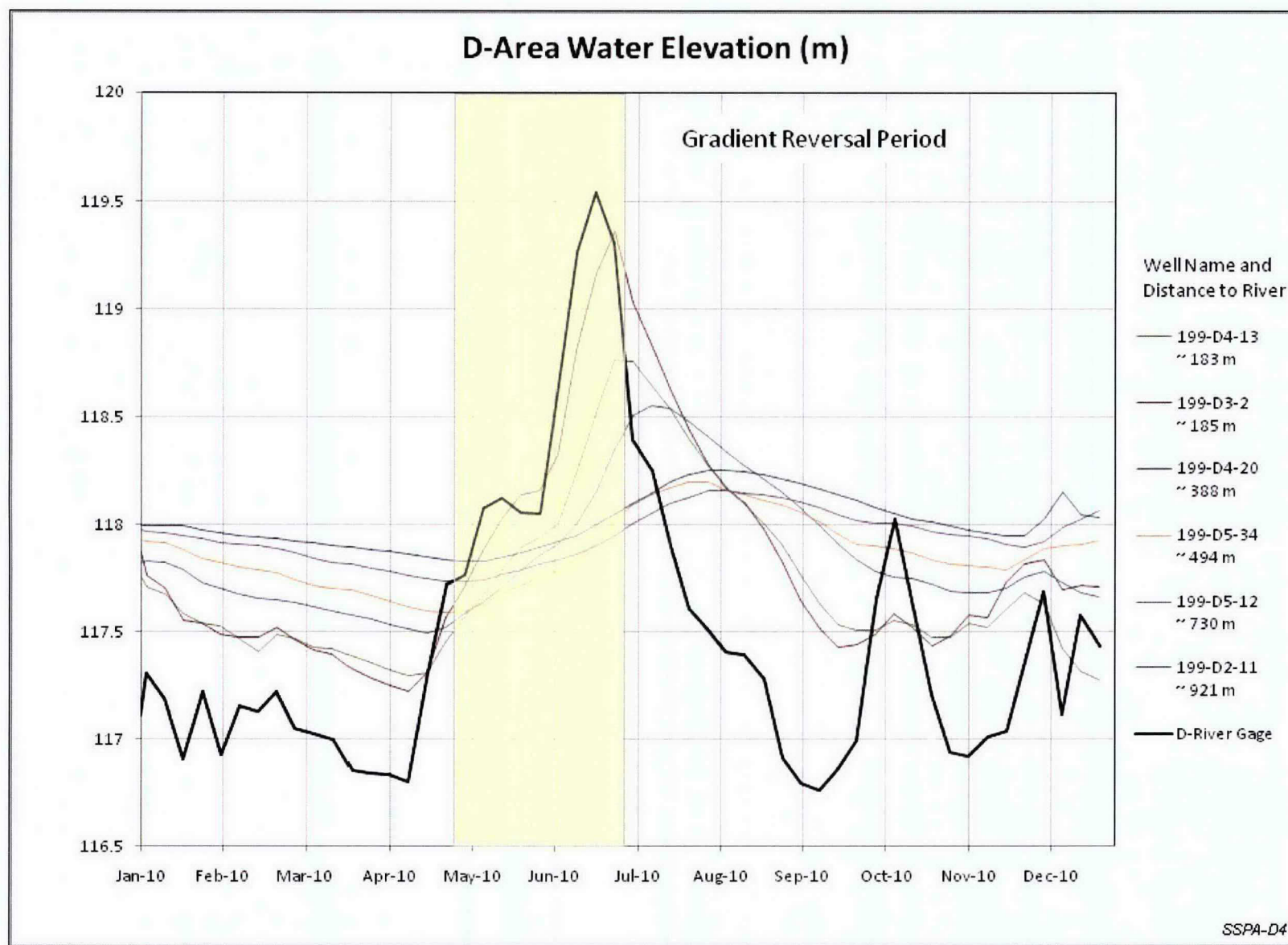
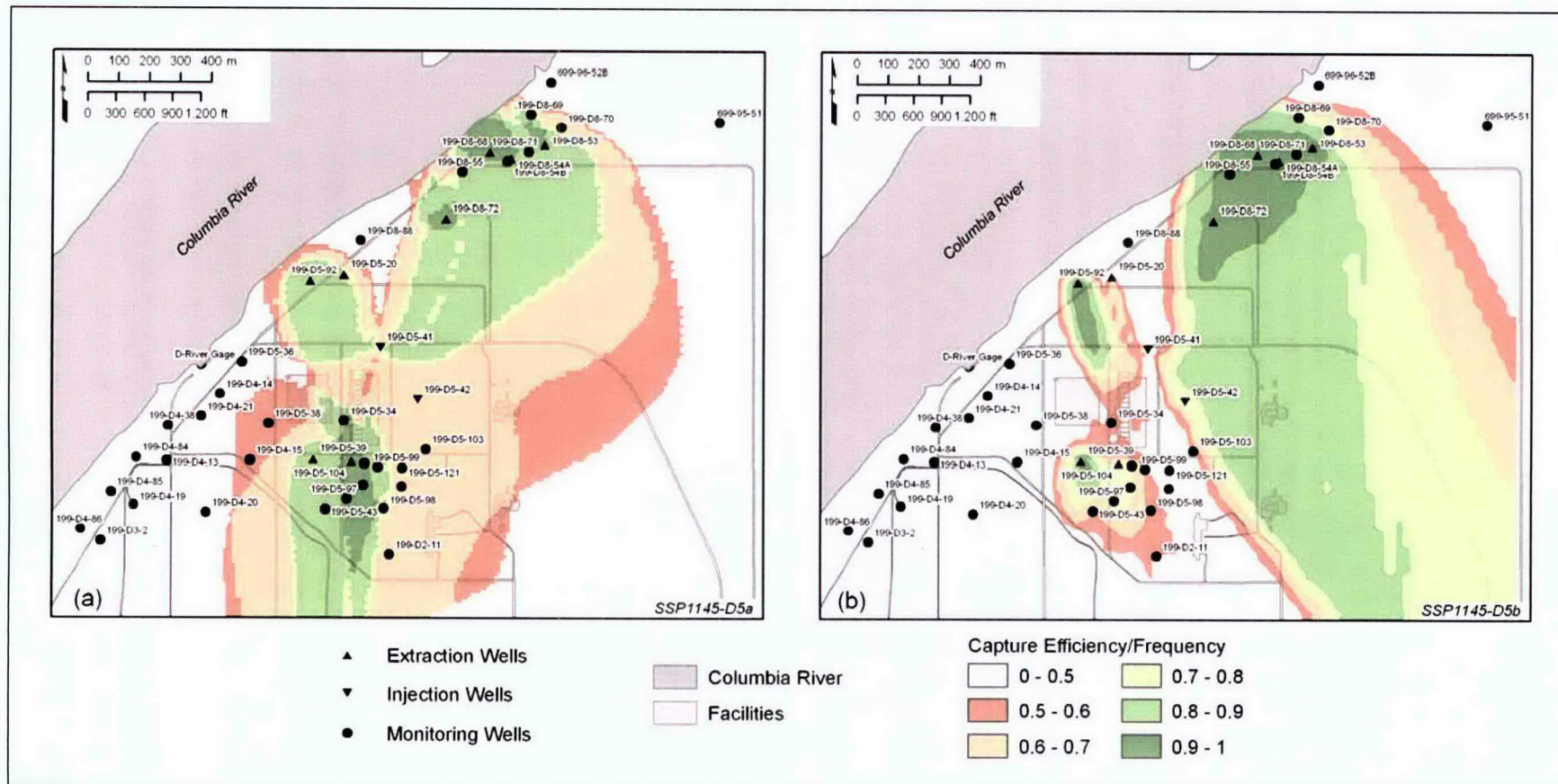


Figure 2-28. Hydrographs for Selected 100-D Area Monitoring Wells with River Stage



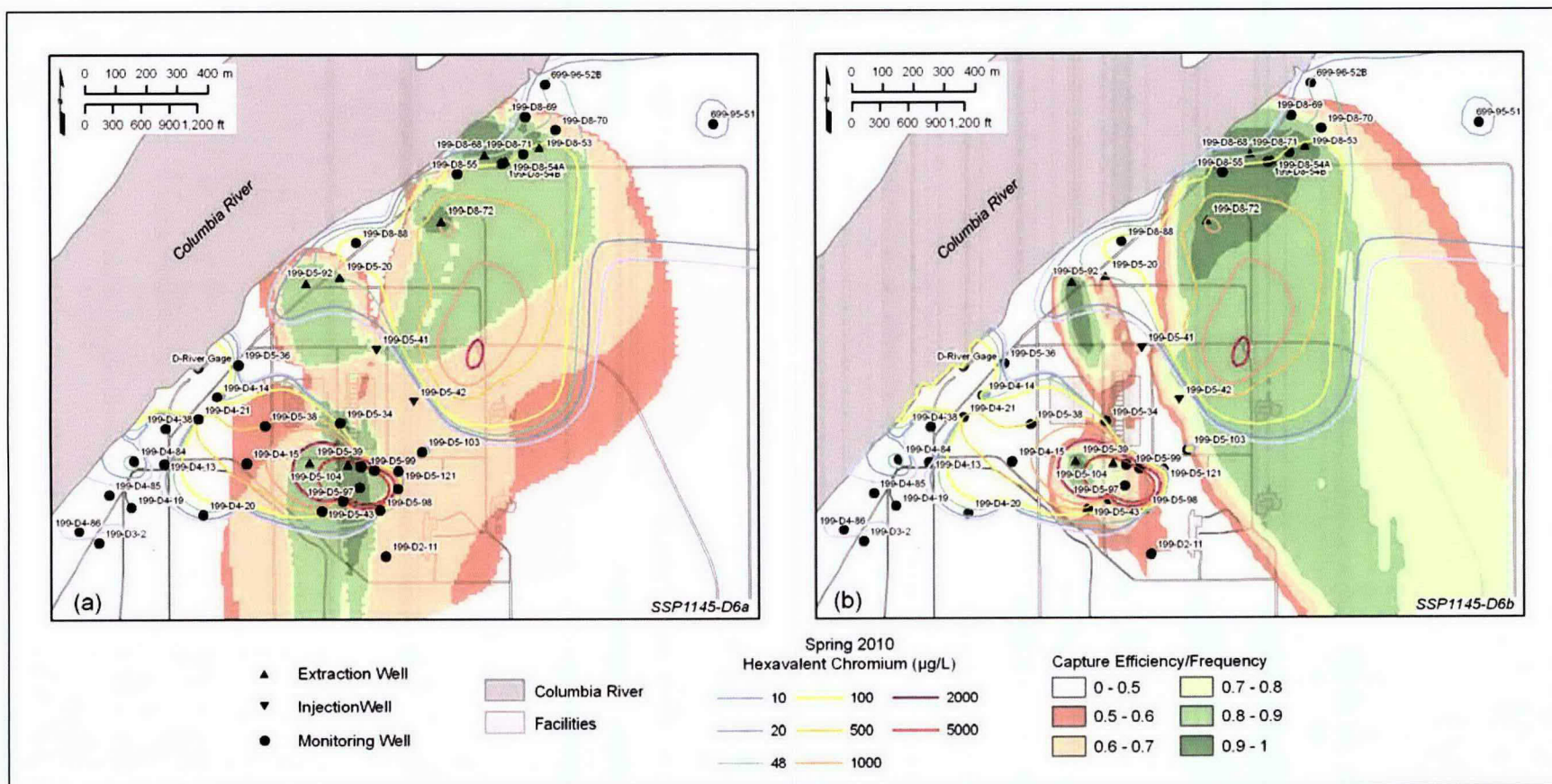


Figure 2-30. Approximate Extent of Capture Throughout the 100-D Area for January to October 2010, Calculated Using (a) Modeling Method and (b) Mapping Method (Overlaid with Spring 2010 Contoured Extent of Hexavalent Chromium)

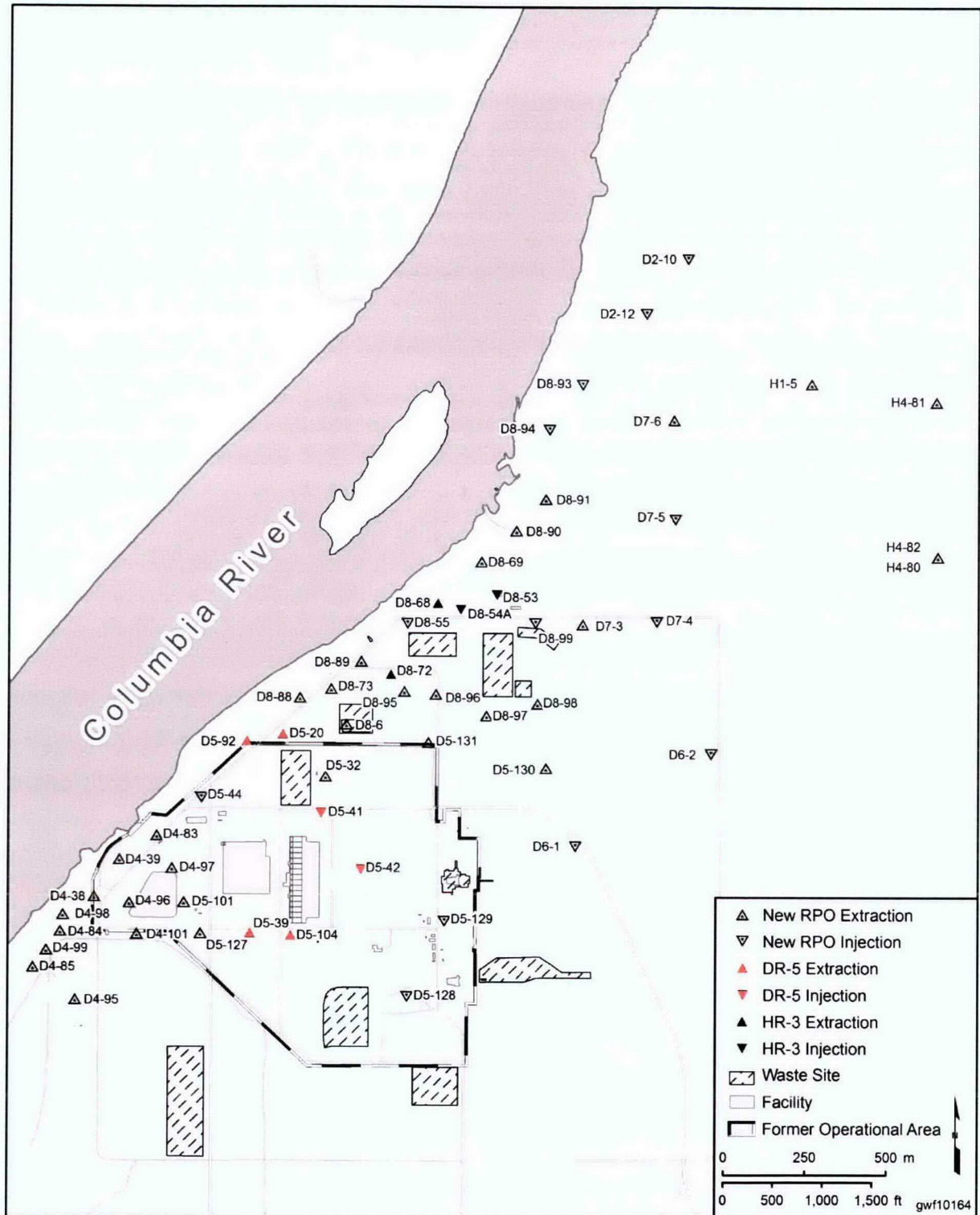


Figure 2-31. RPO Wells in the 100-D Area

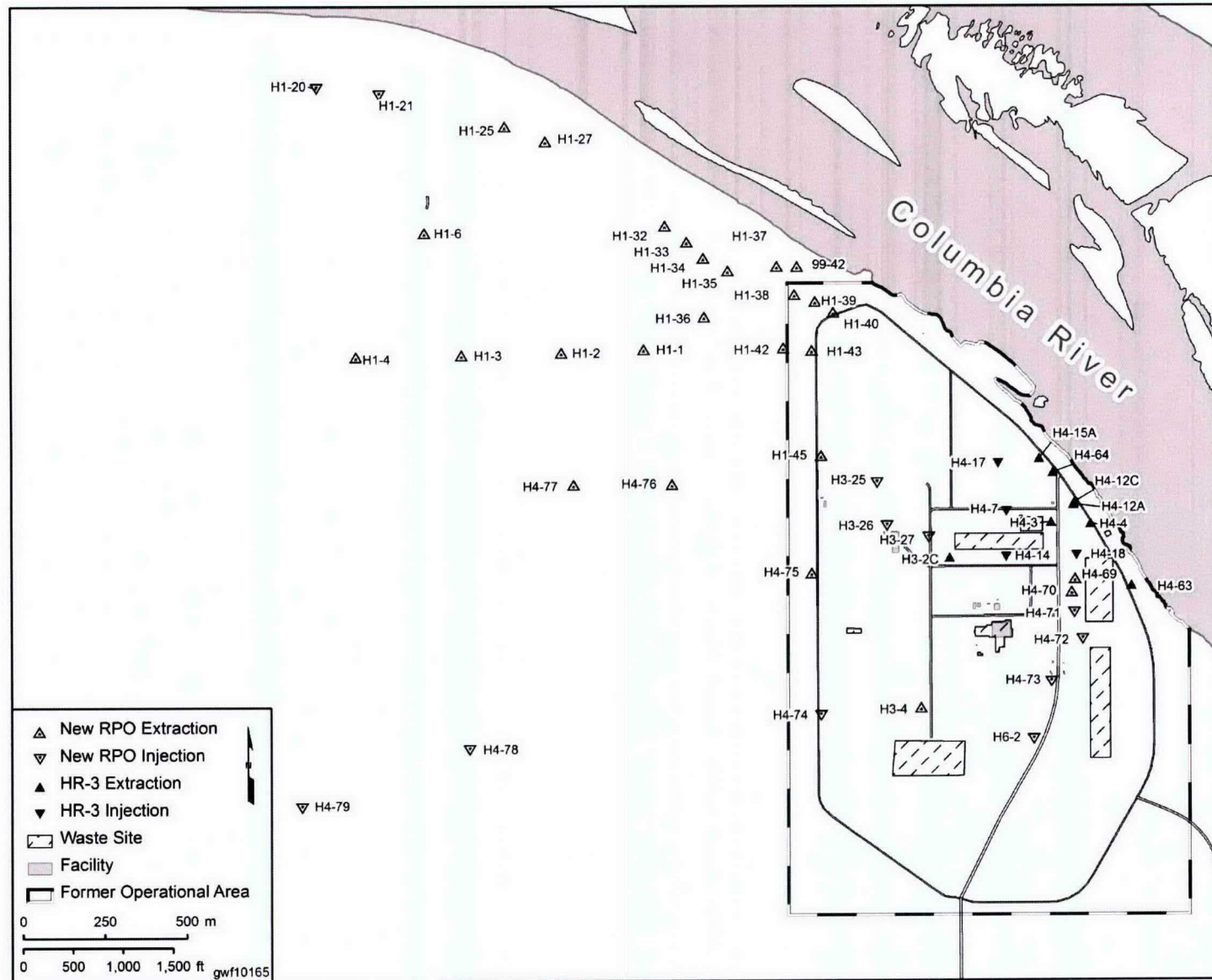


Figure 2-32. RPO Wells in the 100-H Area

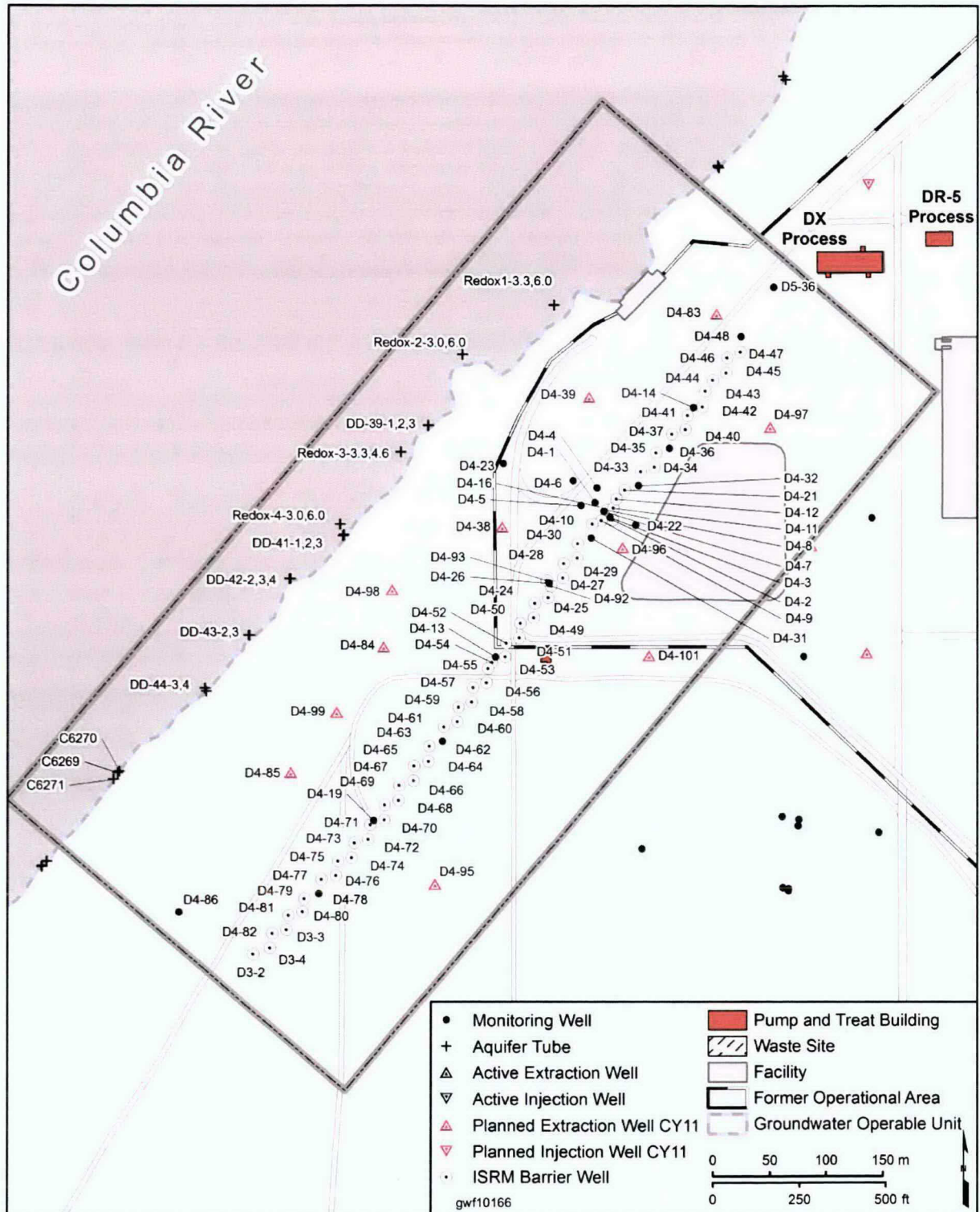


Figure 2-33. ISRM Detail Map

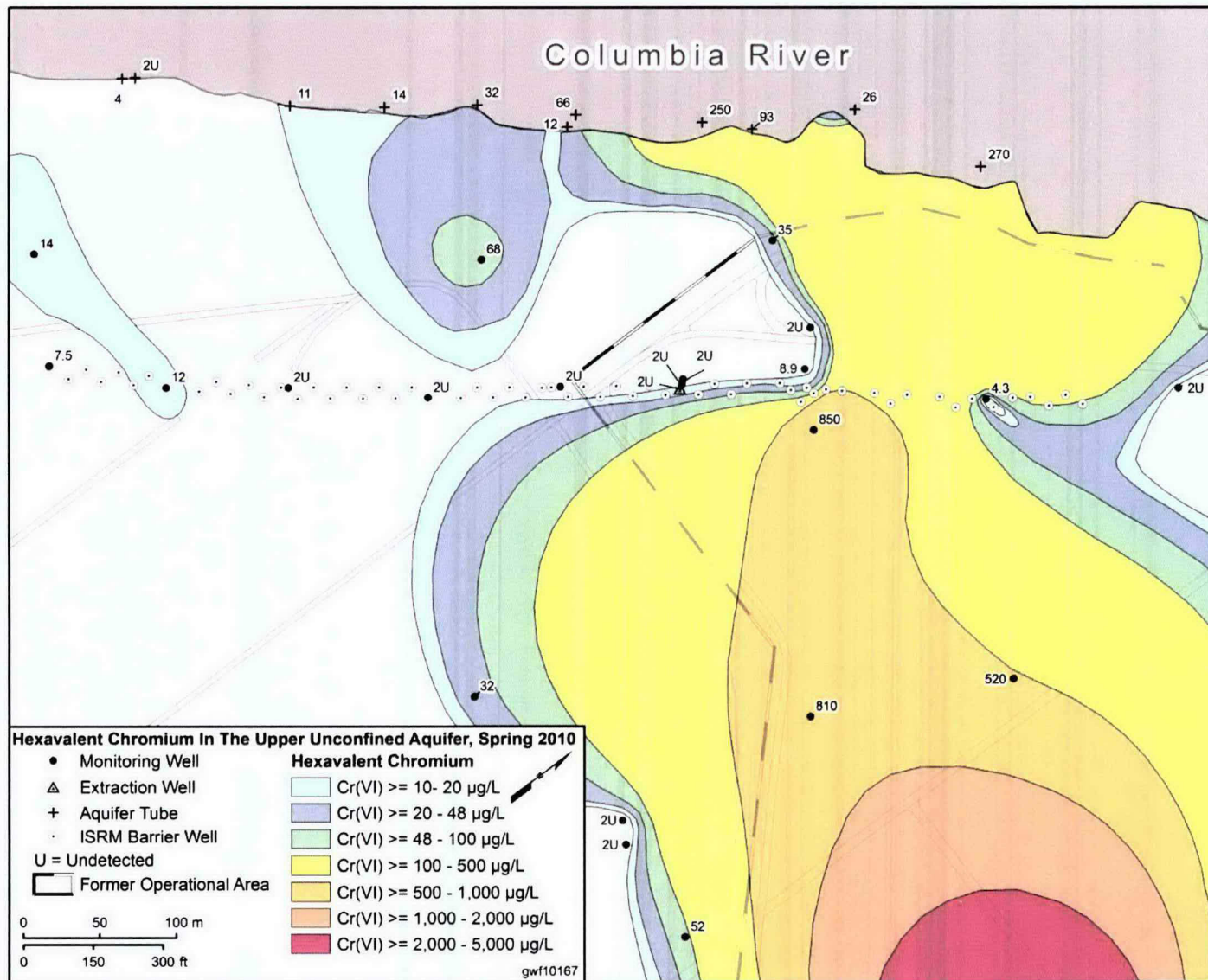


Figure 2-34. ISRM Map

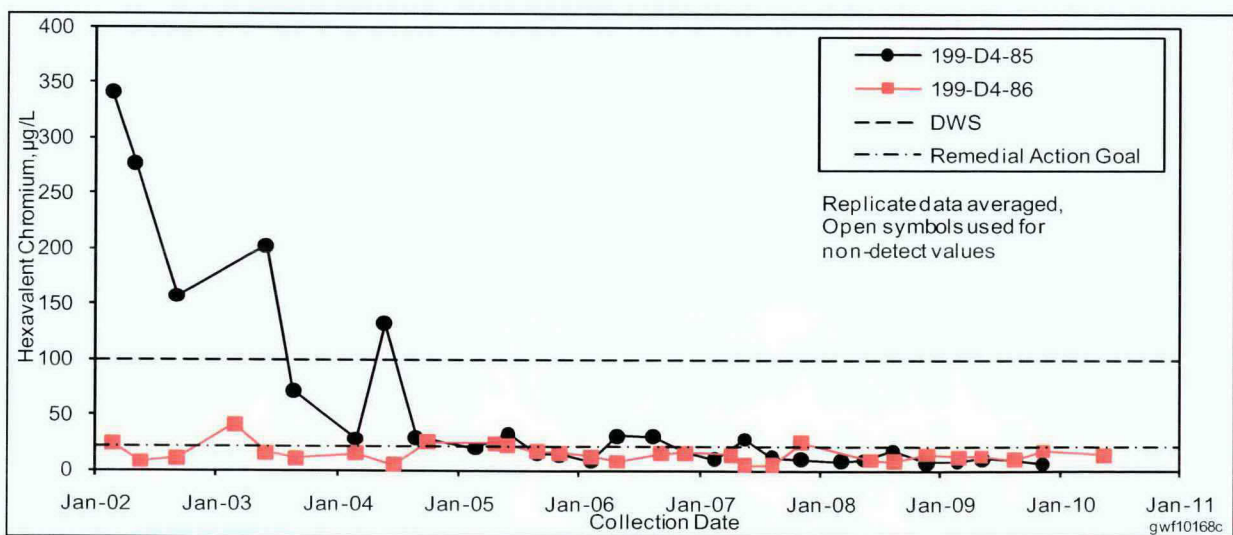
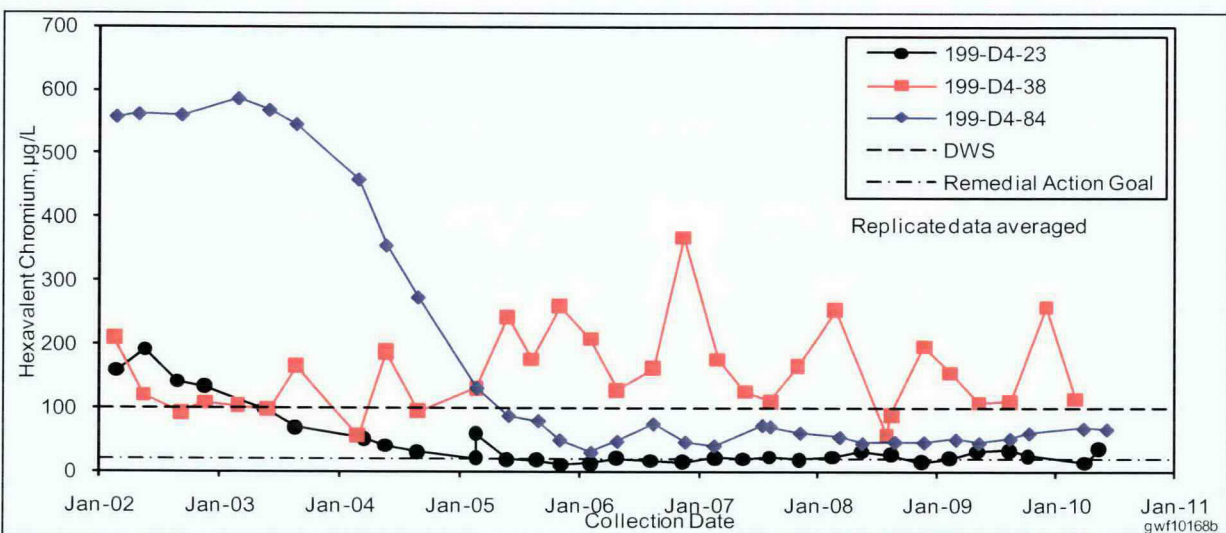
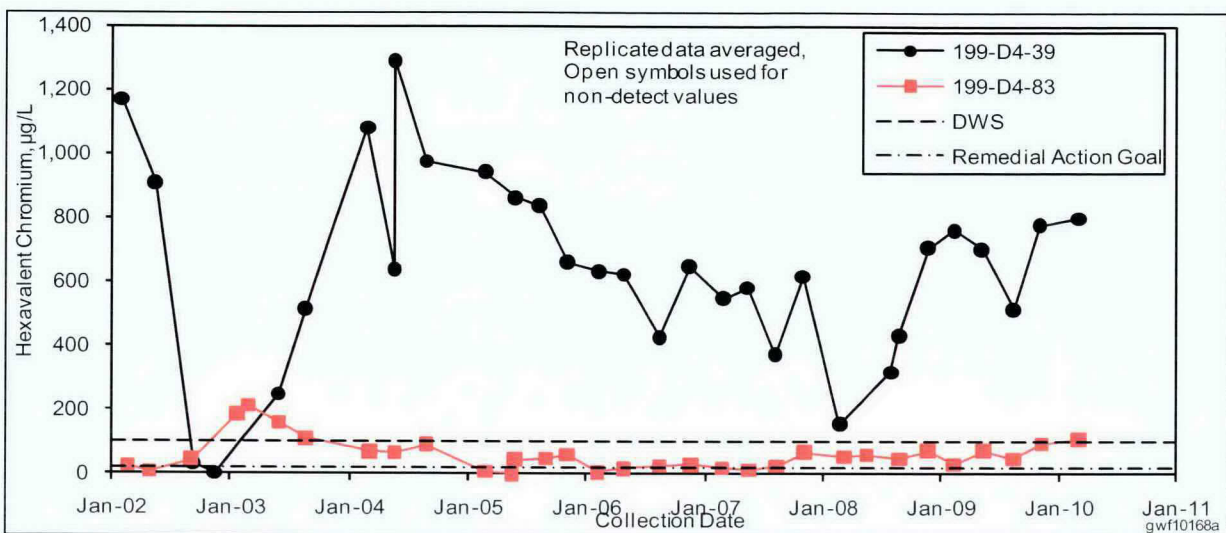


Figure 2-35. Chromium Trend Plots for Compliance Wells

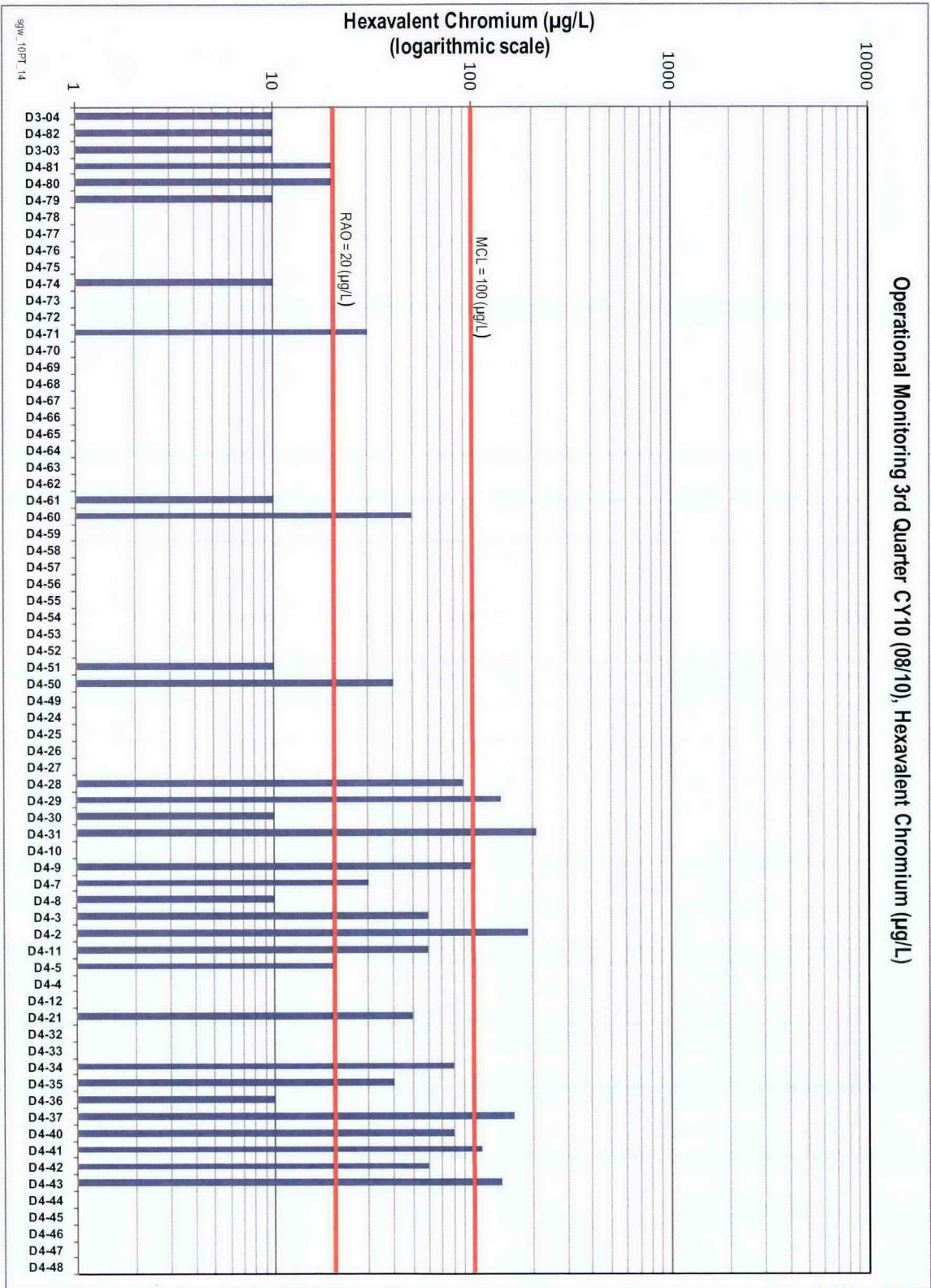


Figure 2-36. ISRM Operational Monitoring, Hexavalent Chromium

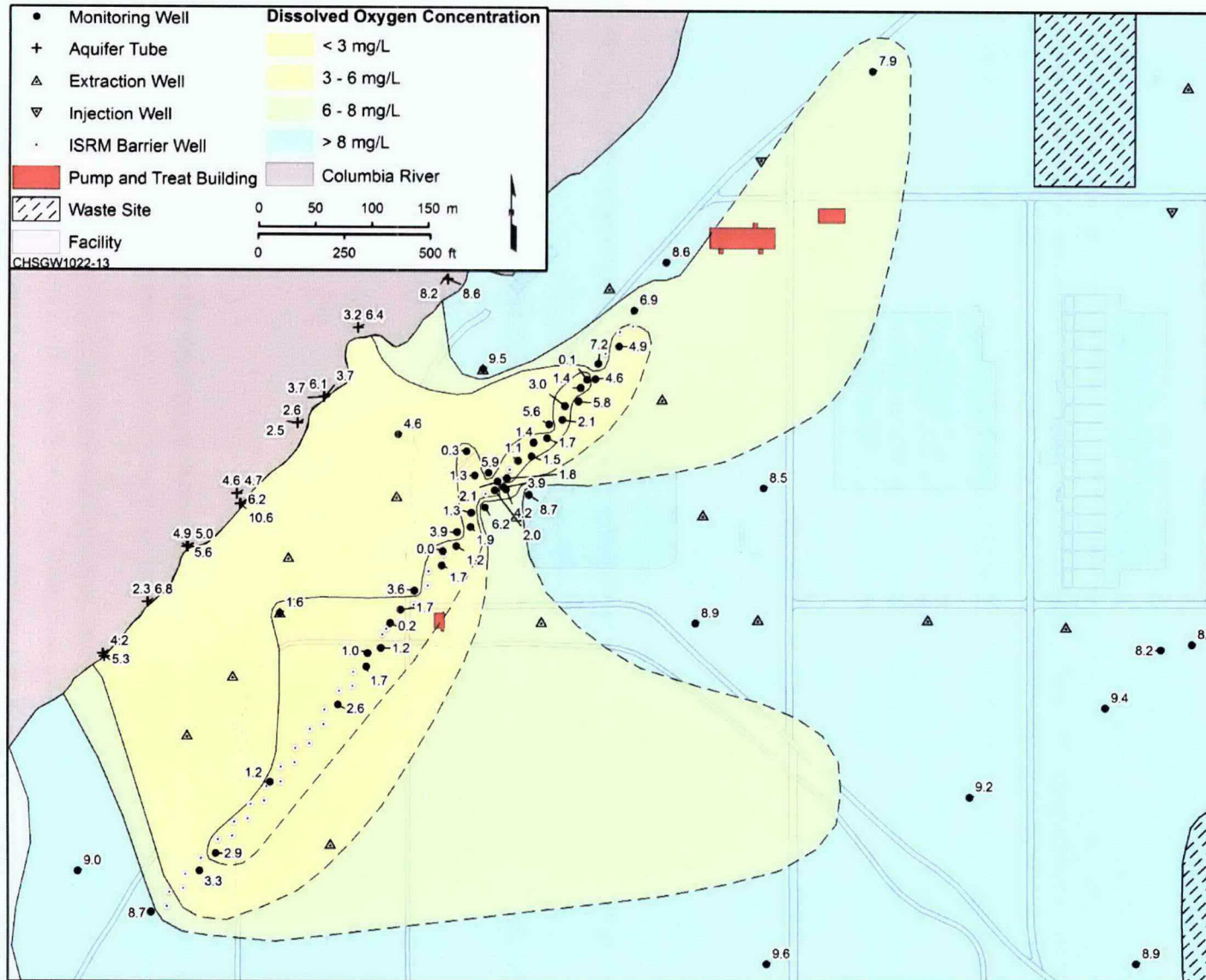


Figure 2-37. ISRM Dissolved Oxygen Concentrations, April to July 2010

**Table 2-1. Maximum Contaminant and Co-Contaminant Concentrations  
for 100-D Area, 2009 and 2010**

<b>Constituent</b>	<b>Maximum Value Detected, µg/L or pCi/L</b>	<b>Filtered (F) or Unfiltered (UF)</b>	<b>Date Sampled</b>	<b>Well Name</b>
<b>2010</b>				
Hexavalent chromium	69,700	F	8/18/10	199-D5-122
Hexavalent chromium	69,100	UF	8/18/10	199-D5-122
Chromium	61,100	UF	2/11/10	199-D5-122
Nitrogen in nitrate	99,200	UF	3/22/10	199-D5-15
Total beta radiostrontium	8.5	UF	11/19/10	199-D3-5
Tritium	20,000	UF	12/2/10	199-D6-3
Technetium-99	2,100	UF	5/12/10	199-D5-18
Sulfate	776,000	UF	4/15/10	DD-43-3
Uranium	5.82	UF	12/2/10	199-D6-3
Gross beta	27	UF	12/13/10	199-D5-40
Gross alpha	9.8	UF	11/30/10	199-D5-133
<b>2009</b>				
Hexavalent chromium	59,600	F	12/15/09	199-D5-122
Hexavalent chromium	58,900	UF	12/15/09	199-D5-122
Chromium	5,750	F	9/15/09	199-D5-99
Chromium	5,750	UF	9/15/09	199-D5-99
Nitrogen in nitrate	95,200	UF	8/28/09	199-D2-6
Total beta radiostrontium	4,200	UF	6/18/09	199-D8-53
Tritium	25,000	UF	11/9/09	199-D4-78
Technetium-99	15	UF	11/20/09	199-D4-95
Sulfate	584,000	UF	11/11/09	DD-43-4
Uranium	4.29	UF	11/2/09	199-D4-14
Gross beta	140	UF	11/2/09	199-D4-19
Gross alpha	11	UF	10/7/09	199-D5-16

**Table 2-2. Maximum Contaminant and Co-Contaminant Concentrations  
for 100-H Area, 2009 and 2010**

<b>Constituent</b>	<b>Maximum Value Detected (µg/L) or (pCi/L)</b>	<b>Filtered (F) or Unfiltered (UF)</b>	<b>Date Sampled</b>	<b>Well Name</b>
<b>2010</b>				
Hexavalent chromium	140	F	12/16/10	199-H4-12C
Hexavalent chromium	139	UF	12/16/10	199-H4-12C
Chromium	133	UF	12/16/10	199-H4-12C
Chromium	128	F	12/16/10	199-H4-12C
Nitrate	44,300	UF	11/5/10	199-H6-3
Total beta radiostrontium	160	UF	6/2/10	199-H1-20
Tritium	5,300	UF	5/16/10	199-H3-3
Technetium-99	94	UF	12/29/10	199-H4-12A
Sulfate	83,600	UF	5/13/10	199-H4-46
Uranium	12.2	UF	1/11/10	199-H4-3
Uranium	11	F	1/11/10	199-H4-3
Gross beta	69	UF	12/13/10	199-H4-13
Gross alpha	12	UF	11/8/10	199-H6-3
<b>2009</b>				
Hexavalent chromium	121	UF	11/19/09	199-H4-12C
Hexavalent chromium	120	F	11/19/09	199-H4-12C
Chromium	215	UF	10/27/09	199-H4-18
Chromium	117	F	11/19/09	199-H4-12C
Nitrate	150,000	UF	10/11/2009	199-H4-6
Total beta radiostrontium	110	UF	10/27/09	199-H4-13
Tritium	11,000	UF	10/11/2009	199-H3-3
Technetium-99	55	UF	12/1/2009	199-H4-3
Sulfate	88,700	UF	10/11/2009	199-H4-46
Uranium	14.4	UF	12/1/2009	199-H4-3
Gross beta	58	UF	10/11/2009	199-H4-13
Gross alpha	4.7	UF	11/5/2009	199-H4-3

**Table 2-3. HR-3 P&T System Existing Wells**

<b>Well Name</b>	<b>Use in CY 2010</b>
199-D8-53	Extraction
199-D8-54A	Extraction
199-D8-68	Extraction
199-D8-69	Compliance
199-D8-70	Compliance
199-D8-72	Extraction
199-H3-2C*	Extraction
199-H4-12A	Extraction
199-H4-12C*	Extraction
199-H4-14	Injection
199-H4-15A	Extraction
199-H4-17	Injection
199-H4-18	Injection
199-H4-3	Extraction
199-H4-4	Extraction
199-H4-5	Compliance
199-H4-63	Extraction
199-H4-64	Extraction

\* RUM well added in CY 2010.

**Table 2-4. 100-HR-3 OU Operating Parameters and System Performance for CY 2010**

<b>Total 100-HR-3 Processed Groundwater</b>	<b>CY 2009</b>	<b>CY 2010</b>
Total amount of groundwater treated (since 1997) (million L)	3,786.9	4,054.8
Total amount of groundwater treated during CY (million L)	177.3	267.9
<b>Mass of Hexavalent Chromium Removed</b>	<b>CY 2009</b>	<b>CY 2010</b>
Total amount of hexavalent chromium removed (since 1997 startup) (kg)	361.9	392.9
Total amount of hexavalent chromium removed in CY (kg)	15.9	31
<b>Summary of Operational and System Availability</b>	<b>CY 2009</b>	<b>CY 2010</b>
Removal efficiency (% by mass)	95.0%	96.0%
Total possible run-time (hours)	8,760	8,760
Scheduled downtime (hours)	218.6	201.2
Planned operations (hours)	8,541.4	8,558.8
Unscheduled downtime (hours)	2,641.8	690.8
Total time online (hours)	5,899.6	7,868
Total availability (%)	67.3%	97.7%
Scheduled system availability (%)	97.5%	89.8%

Notes: Scheduled system availability [(total possible run-time - scheduled downtime) ÷ total possible run-time].

Total availability [(total possible run-time - scheduled and unscheduled downtime) ÷ total possible run-time].

**Table 2-5. DR-5 P&T System Wells**

<b>Well Name</b>	<b>Use in CY 2010</b>
199-D5-20	Extraction
199-D5-32*	Extraction
199-D5-39	Extraction
199-D5-42	Injection
199-D5-92	Extraction
199-D5-104	Extraction
199-D5-41	Injection

\* Well not operating during CY 2010.

**Table 2-6. DR-5 P&T System Operating Parameters and System Performance for CY 2010**

<b>Total DR-5 Processed Groundwater</b>	<b>CY 2009</b>	<b>CY 2010</b>
Total amount of groundwater treated (since December 2004) (million L)	329.4	374
Total amount of groundwater treated during CY (million L)	48.6	44.6
<b>Mass of Hexavalent Chromium Removed</b>	<b>CY 2009</b>	<b>CY 2010</b>
Total amount of hexavalent chromium removed (since August 2004 startup) (kg)	251.3	326.2
Total amount of hexavalent chromium removed in CY (kg)	44.2	74.9
<b>Summary of Operational and System Availability</b>	<b>CY 2009</b>	<b>CY 2010</b>
Removal efficiency (% by mass)	99.9%	99.8%
Total possible run-time (hours)	8,760	8,760
Scheduled downtime (hours)	38.4	165.6
Planned operations (hours)	8,721.6	8,594.4
Unscheduled downtime (hours)	946.3	2,211.1
Total time online (hours)	7,775.3	6,383.3
Total availability (%)	88.8%	98.1%
Scheduled system availability (%)	99.6%	72.9%

Notes: Scheduled system availability [(total possible run-time - scheduled downtime) ÷ total possible run-time].

Total availability [(total possible run-time - scheduled and unscheduled downtime) ÷ total possible run-time].

### 3 100-KR-4 Operable Unit Remediation

This chapter describes the status of the interim remedies for the 100-KR-4 OU, as well as the status of other CERCLA activities for the OU. The following discussion includes the performance of the interim remedy P&T systems, RPO, and a brief summary of the RI/FS.

#### 3.1 Summary of Operable Unit Activities

The 100-KR-4 Groundwater OU lies within the larger 100-K Area (Figure 3-1) and includes the groundwater underlying the 100-KR-1 and 100-KR-2 Source OUs (DOE/RL-2008-46-ADD2). The 100-KR-4 OU comprises groundwater contaminated by releases from facilities and waste sites associated with past operation of the KE and KW Reactors (Figure 3-2). Hexavalent chromium released from these facilities and waste sites poses a risk to human health and/or the environment and was identified in the interim ROD (EPA/ROD/R10-96/134) as the primary COC for groundwater in the 100-KR-4 OU. Interim action co-contaminants for the 100-KR-4 OU include tritium and strontium-90. Carbon-14, nitrate, trichloroethene (TCE), chloroform, and technetium-99 are considered target analytes or constituents of interest that may be addressed as part of a final remedy for this OU. However, no exceedances or near exceedances of chloroform or technetium were detected in the 100-KR-4 OU during 2010; therefore, these constituents are not addressed further in this chapter.

The ROD for the 100-KR-4 OU (EPA/ROD/R10-96/134) defined the cleanup goal for hexavalent chromium in groundwater discharging to the Columbia River based on the ambient water quality criterion of 11 µg/L. Based in part on the allowance that contaminated groundwater (prior to discharging to the river) is mixed on a 1:1 basis with relatively uncontaminated porewater within a near-shore mixing zone along the river, the attainment of less than 22 µg/L as hexavalent chromium in the compliance monitoring well network of the 100-KR-4 OU was deemed to be consistent with the achievement of this RAO. The explanation of significant differences for the 100-KR-3 and 100-KR-4 OUs (EPA et al., 2009) reduced the remediation target for surface water to 20 µg/L. Consequently, a compliance criterion of 20 µg/L hexavalent chromium in groundwater is currently applied to near-shore and compliance wells along the river. The DWS for hexavalent chromium at the 100-K Area inland wells remains at 100 µg/L.

To control and mitigate the risks associated with chromium contamination in groundwater, three CERCLA interim action IX P&T systems have been installed in the 100-KR-4 OU, and all three system were operational for most of CY 2010. The KR4 system was the first system installed, beginning operation in 1997. This system was designed to remediate groundwater around the 116-K-2 Trench (Figure 3-2). The second system installed, the KW system, began remediating hexavalent chromium in the KW Reactor area in January 2007. The third and newest system, the KX system, began operations in February 2009. The KX system is used primarily to treat hexavalent chromium in groundwater that has migrated from the 116-K-2 Trench area to the N Reactor fence line. The extraction and injection wells that comprise the well fields for these systems during CY 2010, as well as the associated monitoring wells and other monitoring locations, are shown in Figure 3-2.

Monitoring, data evaluation, and site characterization activities are conducted each year as part of the ongoing effort to determine or identify (1) whether the 100-KR-4 OU P&T systems are performing as designed, (2) if modifications to the system design or operating parameters will further optimize performance, and (3) the extent of progress toward achieving plume cleanup and river protection RAOs. This chapter discusses the results of the CY 2010 100-KR-4 OU P&T evaluation, including the following:

- Section 3.2 presents an overview of the site conceptual model and any changes in the nature and extent of groundwater contamination.

- Section 3.3 discusses system operations, performance monitoring results, and capture zone analysis of extraction wells.
- Section 3.4 provides a summary of the RPO and RI/FS activities for this OU.
- Sections 3.5 and 3.6 present the conclusions and the recommendations, respectively, for the 100-KR-4 OU.

### **3.1.1 100-KR-4 Operable Unit Pump-and-Treat Systems**

The following discussion describes the general operating status of the three interim action P&T systems and the notable modifications made to these systems during CY 2010.

The KR4 system operated for the first three quarters of CY 2010, until the system was shut down for upgrades on October 5, 2010. Revisions included updating the electrical rack and electrical rack components at all extraction wells to replace the outdated, non-supported equipment with contemporary design similar to that used in the KX P&T system design. Revisions also included software and hardware upgrades for the programmable logic control system to equal that currently used by other P&T facilities. Electrical systems were separated to reduce lock-and-tag issues. Adjustable frequency drive control was added to new wellhead racks, and the new racks were connected by new power and fiber communication cables without conduit to reduce maintenance issues. The KR4 system was restarted on January 15, 2011, under acceptance testing.

The only significant well configuration change was the connection of three extraction wells (199-K-144, 199-K-145, and 199-K-162) to the KR4 system in the first quarter of CY 2010. These wells were formerly part of the extraction well network for the KX treatment system. The KX system operated nearly continuously during CY 2010. Major system modifications included connecting extraction wells 199-K-153 and 199-K-171 to the KX system in the first quarter of CY 2010.

The KW P&T system operated at near capacity throughout CY 2010. The key change at this system was the connection of extraction well 199-K-139 in April 2010.

### **3.1.2 Remedial Investigation/Feasibility Study Activities**

Characterization activities were begun in CY 2010, as described in DOE/RL-2008-46-ADD2 and implemented through the sampling and analysis plan (DOE/RL-2009-41). A drilling program of 13 wells and 2 boreholes was initiated in May 2010 and was approximately 80 percent complete by the end of CY 2010. The drilling campaign was completed in the first quarter of CY 2011. Groundwater and vadose zone sampling at 1.5 m (5 ft) intervals was specified for many of the borings. Screen placement in the final well design was based on the vertical profile for hexavalent chromium in groundwater wells. Preparation of the RI/FS report began in CY 2010 and was completed in March 2011.

### **3.1.3 Remedial Process Optimization Activities**

The RPO studies to improve the effectiveness of remediation and meet target milestones were initiated in CY 2009. Extensive groundwater modeling through repeated updates has been used to design treatment systems relying on P&T and on combined bioremediation/P&T approaches. Modeling has guided two phases of well realignments between treatment systems and is supporting an additional phase of well drilling being implemented in CY 2011. Additional RPO phase activities for bioremediation will follow from decisions of the final ROD for the 100-K Area.

Four wells will be drilled as part of Phase 3 of the RPO activities. Three of the four wells (199-K-196 at the KW system, and 199-K-198 and 199-K-199 at the KR4 system) will be connected to the respective treatment systems, while the fourth well (199-K-197) will monitor groundwater conditions near the

southwest end of the 116-K-2 Trench. These wells are being drilled through the aquifer to the RUM unit to characterize vertical contaminant distribution. All wells will be designed so the well screens intersect the zones of greatest hexavalent chromium concentrations. Well 199-K-196 will be screened deeper in the aquifer to provide coverage in an area otherwise populated with shallow extraction wells. Preliminary results at the first three wells (199-K-197, 199-K-198, and 199-K-199) indicate that hexavalent chromium does not exceed 40 µg/L, and most detections are in the middle or lower portion of the aquifer.

Two monitoring wells within the 100-KR-4 OU (199-K-152 and 199-K-182 at the KX system) will be converted to extraction wells in CY 2011. Former extraction wells 199-K-149 and 199-K-150 are currently designated as monitoring wells and may be converted to injection wells as cleanup progresses and plume sizes shrink.

## 3.2 Conceptual Site Model

The conceptual site model for the 100-KR-4 OU is discussed in this section. The geology, hydrology, and major ion hydrochemistry for the OU are described, as well as the OU groundwater contaminants.

### 3.2.1 Geologic/Hydrogeologic Setting

#### 3.2.1.1 Geology

The surficial deposits at the 100-K Area consist of recent backfill sand and gravel overlying Holocene aeolian deposits (Figure 3-3). Construction backfill varies in depth depending on the excavated depth of waste sites and building foundations, and backfill material may cover larger graded areas to a depth of up to 4.6 m (15 ft). Where not disrupted by construction activities, Holocene surficial deposits form a thin (0.3 m [1 ft]) veneer and consist of fine-grained aeolian deposits (loess) and Columbia River deposits of silt, sand, and gravel (WHC-SD-EN-TI-155, *Geology of the 100-B/C Area, Hanford Site, South-Central Washington*).

These surface deposits are underlain, in descending order, by the Hanford formation, the Ringold Formation, and by bedrock consisting of Columbia River Basalt Group. The Hanford formation and the Ringold Formation are described below. Figure 3-3 presents a generalized cross section of the geology beneath the 100-K Area.

#### **Hanford Formation**

The informally named Hanford formation overlies the late Miocene to middle Pliocene Ringold Formation in the 100-K Area and consists of boulders, gravel, sand, and silt deposited by cataclysmic glacial Lake Missoula Ice Age floods that occurred during the Pleistocene epoch (DOE/RW-0017, *Draft Environmental Assessment: Reference Repository*). The Hanford formation is comprised of gravel-dominated, sand-dominated, and silt-dominated sequences of which only the upward-fining, gravel-dominated unit occurs in the 100 Area along the Columbia River (DOE/RL-2002-39, *Standardized Stratigraphic Nomenclature for Post-Ringold Formation Sediments Within the Central Pasco Basin*). The Hanford formation is the dominant material in the 100 Area vadose zone, ranging in thickness from less than 1 m (3.3 ft) near the river shoreline, to 20 m (65 ft) along the southern edge of the K Reactor area, and to approximately 30 m (100 ft) near the southeastern boundary of the 100-K Area (WHC-SD-EN-TI-011, *Geology of the Northern Part of the Hanford Site: An Outline of Data Sources and the Geologic Setting of the 100 Areas*). The unit thins nearer the shoreline of the Columbia River and becomes mixed with terrace gravel deposits laid down by the ancestral Columbia River. The Hanford formation underlying the 100-K Area essentially comprises a sand and gravel wedge that generally coarsens eastward (DOE/RL-2002-39). The Hanford formation has been eroded in locations to where the underlying Ringold Formation is exposed along the riverbank and up to 366 m (1,200 ft) inland (EPA/ROD/R10-96/134).

### **Ringold Formation**

The Miocene-Pliocene Ringold Formation disconformably underlies the Hanford formation and unconformably overlies the Columbia River Basalt Group (Figure 3-3). It has a maximum thickness of approximately 185 m (600 ft) in the Pasco Basin and a maximum thickness of 161 m (527 ft) in the 100-K Area. During the Pleistocene flood events that produced the Hanford formation in the 100-K Area, the Ringold Formation experienced widespread erosion that resulted in an irregular contact between the two units. This contact presents a contrast between the loose, permeable, coarse Hanford deposits and the denser, less-permeable, locally cemented Ringold Formation unit E gravels.

The Ringold formation is divided into three units: the lowest Wooded Island, and the Taylor Flats and uppermost Savage Island members. The upper two members of the Ringold Formation consist of interbedded fluvial sand and overbank facies overlain by mud-dominated lacustrine facies (WHC-SD-EN-EE-004, *Revised Stratigraphy for the Ringold Formation, Hanford Site, South-Central Washington*). These members are absent in the 100-K Area and other 100 Area reactor areas but are preserved in the White Bluffs on the eastern side of the Columbia River.

The Wooded Island member of the Ringold Formation present in the 100-K Area consists of four water-bearing, stratigraphic intervals dominated by fluvial gravels and sand. These lower Ringold units are designated, in descending stratigraphic order, as units E, C, B, and A; unit D is missing locally. These units are separated by, and interbedded with, two widespread mud and silt deposits of overbank and lacustrine origin (BHI-00184, *Miocene- to Pliocene-Aged Suprabasalt Sediments of the Hanford Site, South-Central Washington*). In the 100 Area, the shallowest overbank deposits are known informally as the RUM. Ringold Formation unit E is the uppermost coarse-grained unit of the Ringold Formation present in the 100-K Area, and it comprises the majority of the shallow unconfined aquifer. This unit is composed of loose to semi-indurated clay, silt, fine- to coarse-grained sand, gravel, and cobbles. Hydraulic conductivities vary locally, but the Ringold Formation unit E is generally regarded as a low-conductivity unit.

The Ringold Formation unit E is underlain by the low-permeability, silt- and clay-rich RUM. The RUM is up to 60 m (200 ft) thick in the 100-K Area and floors the shallow unconfined aquifer in the 100-K Area. In general, the surface of the RUM dips toward the Columbia River. The RUM/Ringold Formation unit E contact is also disconformable with evidence of erosion by the ancestral Columbia River system that deposited the Ringold Formation unit E.

#### **3.2.1.2 Hydrogeology**

Long-term groundwater flow in the vicinity of the 100-K Area is toward the Columbia River and occurs primarily in the low to moderately permeable sands and gravels of the Ringold Formation unit E. The saturated thickness of the Ringold Formation unit E ranges from 5.2 m (17 ft) at well 199-K-161 to more than 32 m (105 ft) in the 100-K Area. The mean transmissivity value obtained from constant discharge tests in 100-KR-4 injection wells was approximately 90 m<sup>2</sup>/day (969 ft<sup>2</sup>/day). The underlying silt- and clay-rich RUM is considered an aquitard rather than an aquiclude. Measurements of hydraulic conductivity of the Ringold Formation unit E ranged from approximately 0.98 to 44.2 m/day (3 to 145 ft/day) in monitoring wells 199-K-108A and 199-K-37, respectively. Along the 116-K-2 Trench, hydraulic conductivities ranged between 0.9 and 34 m/day (3 and 111 ft/day), with the greatest conductivity value near the center of the trench.

The stage of the Columbia River is controlled at the Priest Rapids Dam and is strongly influenced by short-term and seasonal fluctuations in flow rates due to both natural and manmade effects (e.g., spring snowmelt and runoff). Even short-term fluctuations in the discharge rates from Priest Rapids Dam are

known to cause river elevations to change by as much as 2.7 m (9 ft) in a single day (PNL-9437, *Monitoring Groundwater and River Interaction Along the Hanford Reach of the Columbia River*).

The water table elevation and groundwater flow direction within the aquifer proximal to the river is strongly and rapidly influenced by even short-term changes in river stage. Longer term seasonal changes in the river stage produce longer term increases in the water table elevation that gradually extend further inland over time (up to several thousand feet) from the river, while the magnitude of the increase progressively decreases with distance from the river.

In response to the seasonal changes in river stage, the groundwater flow gradients in the 100-KR-4 OU steepen toward the Columbia River during seasonal periods of low river flow (i.e., in the fall and winter) (Figure 3-4). Conversely, the groundwater gradient flattens as river water infiltrates into the aquifer during the spring when the river stage is high (Figure 3-4).

The hydraulic effects of the P&T systems at the 100-KR-4 OU are superimposed onto these broad seasonal fluctuations, and the efficiencies of the treatment systems (i.e., mass of hexavalent chromium captured per unit volume of water extracted) typically decrease during high river stage. The effects of seasonal changes in river stage (and water table elevation) on contaminant concentrations in the aquifer and treatment system performance are discussed in Section 3.3.

### **3.2.1.3 Major Ion Groundwater Chemistry**

An evaluation of the major ion chemical characteristics of the groundwater associated with the different hexavalent chromium plumes (i.e., K West, K East, KR4, and K North plumes) within the 100-KR-4 OU is presented in Appendix A and is summarized in the following discussion.

The groundwater of the shallow unconfined aquifer (RUM) has a pH generally ranging between 7.5 and 8.5, with a DO concentration averaging approximately 8.0 mg/L (Appendix A). All of the samples evaluated can be classified as predominantly calcium bicarbonate waters that also contain notable but variable sulfate and nitrate concentrations. Mineral saturation/solubility calculations indicate that the groundwater of the unconfined aquifer is saturated, or nearly saturated, with respect to calcite.

Elevated levels of chloride, relative to the typical groundwater sampled in the 100-KR-4 OU, were noted in groundwater from monitoring well 199-K-110A, located near the KE Reactor and KE fuel rod basin (KE Basin) (Figure 3-2). The DO concentration of this chloride-rich water was approximately 6.6 mg/L, near the lower end of the range of DO values observed for the 100-KR-4 OU. The origin of the high chloride component and the relatively low DO concentrations of the water in this area is uncertain but may reflect disposal activities at the KE Reactor and KE Basin.

The major ion chemistry of groundwater sampled from monitoring well 199-K-135 and other wells located at the calcium polysulfide (and vegetable oil injection) test site (Figure 3-2) is substantially different than groundwater from elsewhere in the OU. Calcium and alkalinity values are three- to four-fold higher than typically found elsewhere in the OU. The DO (at 2.8 mg/L), sulfate, and nitrate concentrations are all notably lower in this area, consistent with ongoing biogeochemical reduction of reduction-oxidation sensitive groundwater and aquifer matrix constituents in the test area. Depending on the extent of groundwater with these geochemical characteristics in the former treatment area and the longevity of continuing bio-geochemical reduction, nearby downgradient extraction wells may be subject to increased rates of mineral and/or biological fouling and associated loss of extraction capacity. This situation will continue to be monitored when sampling at these wells is restarted.

### 3.2.2 100-KR-4 Operable Unit Groundwater Contaminants

The groundwater contamination in 100-KR-4 OU is primarily the result of the operation of two now inactive, water-cooled nuclear reactors (KE and KW Reactors) and the associated structures (e.g., fuel storage basins) and waste disposal processes associated with reactor operations. During operation of these reactors, large quantities of liquid and solid wastes (e.g., contaminated reactor cooling water, fuel storage basin water, and decontamination solutions) were generated and released to the environment, resulting in contamination of 100-K Area groundwater by a range of constituents that are discussed below.

Hexavalent chromium has been identified as the primary COC for groundwater in the 100-KR-4 OU, and strontium-90 and tritium are listed in the ROD for the OU (EPA/ROD/R10-96/134) and are monitored as secondary COCs. Target analytes include carbon-14, nitrate, and TCE, which are also of interest because they have exceeded their maximum contaminant levels (MCLs) in some wells or because these analytes were identified as constituents of interest in a qualitative risk assessment documented in the *100-KR-4 Operable Unit Focused Feasibility Study* (DOE/RL-94-48). Additional analytes may be developed from RI risk assessment activities.

The primary objectives of this section are to (1) summarize and evaluate the analytical results for hexavalent chromium, tritium, strontium-90, carbon-14, nitrate, and TCE obtained from groundwater monitoring locations within the 100-KR-4 OU during the fall of CY 2010; and (2) construct updated spring and fall 2010 plume maps for these constituents.

Contaminant concentration data are collected each year from the 100-KR-4 OU compliance wells, other monitoring and extraction wells, and aquifer tubes that have been properly installed and sited within the OU. The data are used to update the status of the plumes and evaluate the effectiveness of ongoing remedial activities. Particular emphasis is given to data collected during the fall of each year when river levels are low and contaminant concentrations are the highest and most widespread. As discussed in Chapter 1, the planned scope of the fall 2010 monitoring event was not achieved and numerous monitoring wells were not sampled; therefore, only some of the aquifer tubes associated with the 100-KR-4 OU were sampled.

The available fall CY 2010 monitoring results for hexavalent chromium, tritium, strontium-90, carbon-14, nitrate, and TCE at the 100-KR-4 OU are presented in Tables 3-1 through 3-15. If fall 2008 and 2009 data for any of these constituents were previously collected at the locations monitored during fall 2010, the older data were also included in these tables. Where sufficient data were available, the concentration trends of these constituents between the fall of 2008 and 2010 were evaluated. The percent increase or percent decrease in the concentrations of the contaminants of interest between 2008 and 2010, and between 2009 and 2010, are also presented in the data summary tables. Longer term changes in hexavalent chromium concentrations at selected monitoring and extraction wells in the 100-KR-4 OU are addressed as part of the CERCLA system performance assessment (Section 3.3).

The CY 2010 spring and fall plume maps for hexavalent chromium, tritium, strontium-90, carbon-14, nitrate, and TCE for the 100-KR-4 OU are presented in Figures 3-5 through 3-10. Due to the work stoppage during October 2010, the normal fall sampling event was truncated, and many of the groundwater monitoring locations that would be used to create the fall 2010 plume maps were not sampled in October as scheduled. Therefore, analytical data from samples collected from these locations in September, November, or December 2010 were included in the fall 2010 data set in lieu of the missing October data. Despite the incorporation of these supplemental data, the resulting fall 2010 data set was less robust than in previous years. Consequently, the existing fall 2009 hexavalent chromium plume contours were used as a starting point and then modified on the basis of the available fall 2010 data. The fall 2009 plume contours were not modified unless justified by data collected in September through

December 2010. This approach is based on the assumption that the gross nature and extent of the plume has not changed significantly since fall 2009 and that modifications of the 2009 contours were appropriate where fall 2010 data were available. Dashed lines are used in the figures to identify those contours or contour sections where fall 2010 data are particularly sparse or absent, and the contours primarily reflect the 2009 data. Data from RI wells were not used in the plume maps; sampling from the screened wells was not started until after well acceptance in March 2011.

The revised spring and fall 2010 plume maps, data summary tables, and a summary of notable data observations are presented in the following subsections for hexavalent chromium, tritium, strontium-90, carbon-14, nitrate, and TCE.

### **3.2.2.1 Hexavalent Chromium**

The 100-KR-4 OU hexavalent chromium distribution plume map for spring and fall 2010 is presented in Figure 3-5. The data used to construct the CY 2010 hexavalent chromium plume maps were obtained from unfiltered samples analyzed at the Waste Sampling and Characterization Facility laboratory or offsite laboratories. Where more than one analytical result was available, the highest concentration was selected rather than averaging the results. As a result of the influx of river water into the aquifer during the spring, the mapped extent and absolute hexavalent chromium concentrations in the aquifer (and of the co-contaminants discussed later in this section) are generally higher during the fall.

The hexavalent chromium distribution within the 100-KR-4 OU may be depicted as four separate plumes that can be differentiated by geographic location and/or source area. Primary release sites for hexavalent chromium include the 116-K-2 Trench and the 183.1-KE and -KW headhouses. Secondary sites include leaks at the former 107-KE and 107-KW retention basins, post-reactor cooling water pipelines, and the 116-K-1 Crib. The post-reactor cooling water was characterized by hexavalent chromium concentrations of approximately 700 to 170  $\mu\text{g/L}$  in groundwater, values which declined with operational refinements to corrosion protection. Prior to 2006, the mapped distribution of hexavalent chromium in the 100-KR-4 OU consisted of the two relatively small plumes currently present in the KW and KE Reactor areas and a much larger plume associated with the 116-K-2 Trench (Appendix B).

Leaks and spills have yielded hexavalent chromium concentrations in groundwater greater than 700  $\mu\text{g/L}$ , to as high as 4,900  $\mu\text{g/L}$  at the KE and KW headhouses. A plume associated with the KW Reactor is identified as far upgradient as the headhouse structure and extends close to the Columbia River. Concentrations have reached as high as 3,300  $\mu\text{g/L}$  in extraction wells upgradient of the KW Reactor. A similar plume may have existed at the KE headhouse, but little evidence for the plume exists at present. Chromium contaminant trends at well 199-K-36 showed spikes above 1,000  $\mu\text{g/L}$  in 2001. A small plume downgradient of the KE Reactor at wells 199-K-141 and 199-K-178 is attributed to losses at the KE headhouse.

The development of the 116-K-2 Trench plume was consistent with the very large volumes (37,850 to 75,700 L/min [10,000 to 20,000 gpm]) of spent reactor coolant water that was discharged to the 116-K-2 Trench between 1955 and 1971. The P&T activities that began near the 116-K-2 Trench in 1997 gradually have reduced the hexavalent chromium concentrations in the central section of the 116-K-2 Trench plume (between the trench and the river) to near or below 20  $\mu\text{g/L}$  by 2006. Due in part to higher local hydraulic conductivities near the middle of the trench, these remedial actions eventually split the plume into separate northern and southern components (Appendix B), hereafter identified (from northeast to southwest) as the K North plume and the KR4 plume. Additional characterization and monitoring activities conducted since 1997 have mapped the K North plume progressively farther to the northeast, to where it currently extends to the 100-N Area fence line (Figures 3-2 and 3-5). The KR4 plume represents either the residual 116-K-2 Trench plume caught within low-conductivity

Ringold Formation unit E sediments or a combination of 116-K-2 Trench plume combined with diluted KE headhouse losses. Some activation of this plume may be the result of remediation activities at the 118-K-1 Burial Ground.

### **116-K-2 Trench Area (K North and KR4)**

Both the K North and the KR4 hexavalent chromium plumes are larger than the KE or KW Reactor plumes and are being actively remediated by the KR4 and KX P&T systems.

The K North plume generally extends between the northeastern third of the 116-K-2 Trench and the N Reactor fence line (Figure 3-5). The K North plume can be further subdivided into a southwestern lobe and a northeastern lobe where concentrations have exceeded 50 mg/L. Each of these plume lobes is centered on separate small zones of hexavalent chromium with concentrations that currently exceed 48 µg/L and are at, or just below, the 100 µg/L DWS (Figure 3-5). These separate small zones of elevated concentrations are enveloped by a large contiguous area of lower hexavalent chromium concentrations (i.e., greater than or equal to 20 µg/L and less than or equal to 48 µg/L) that defines the bulk of the K North plume (Figure 3-5). Upgradient extents of these plumes suggest that considerable mass may remain to be treated. In the northeastern lobe, the plume is not bounded beyond well 199-K-182. The overall pumping strategy employed in this area should be evaluated to determine if the center of mass for each of these higher concentration plume zones should be more directly targeted for remediation.

The KR4 plume comprises the southern remnant of the former plume in the vicinity of the 116-K-2 Trench and is substantially smaller than the K North plume. The KR4 plume overlaps the southern end of the 116-K-2 Trench and contains a small core zone with concentration of hexavalent chromium that exceeded 100 µg/L (Figure 3-5). Concentrations at this zone declined below 100 µg/L in 2011 for the first time since 2002.

Table 3-1 presents the CY 2010 hexavalent chromium concentrations from wells and aquifer tubes associated with the KR4 and K North plumes and from the intervening central area of the 116-K-2 Trench. Table 3-1 also includes the available 2008 and 2009 data collected at these locations. Notable observations concerning the nature and extent of hexavalent chromium concentrations in the 116-K-2 Trench area data presented in Table 3-1 are summarized below:

- The hexavalent chromium concentrations between the river and the central section of the 116-K-2 Trench (i.e., between the KR4 and K North plumes) have been reduced to less than 20 µg/L. Monitoring wells 199-K-21 and 199-K-117A, and extraction wells 199-K-119A and 199-K-127, have been characterized by hexavalent chromium concentrations less than 20 µg/L since 2008. Additionally, hexavalent chromium concentrations were less than 20 µg/L in monitoring well 199-K-19 and extraction well 199-K-120A in the fall of 2010.
- Fall 2010 hexavalent chromium concentrations were less than 20 µg/L in 17 of 36 wells sampled.
- Hexavalent chromium concentrations decreased or were stable (results compared included “U” [nondetect] qualifiers) in 22 of 25 wells from 2009 to 2010 and in 27 of 28 wells from 2008 to 2010.
- The maximum fall 2010 hexavalent chromium concentration was 139 µg/L in well 199-K-18, which is a decrease of 27.6 percent from the concentration of 192 µg/L in observed in 2009. Concentrations have continued to decrease in 2011. Hexavalent chromium concentrations had been increasing in this well since the start of KR4 P&T system operations in 1997. Recent data suggest that the nearby KR4 system extraction wells 199-K-145 and 199-K-162 are beginning to notably reduce the mass remaining in this portion of the plume.

- Well 199-K-145, located downgradient of well 199-K-18, is the only well downgradient of the 116-K-2 Trench in with an increase in hexavalent chromium concentrations from 37 to 62  $\mu\text{g/L}$  between 2008 to 2010. This could be the result of gradient manipulation pulling contaminated groundwater towards this well.
- Well 199-K-22, located within the area of the former 116-K-2 Trench, displayed high hexavalent chromium concentrations from 2008 to 2010 and also consistently during the period of P&T operations. Concentrations at well 199-K-22 have shown signs of decrease in early 2011.
- An insufficient number of aquifer tubes were sampled in fall 2010 to comment on the effects of the P&T operations on hexavalent chromium concentrations along the shoreline adjacent to the 116-K-2 Trench.
- The extent of the contamination that has historically been associated with the 116-K-2 Trench continued to decrease during 2010. Reductions in the extent of contamination are particularly notable in the central area of the 116-K-2 Trench (e.g., wells 199-K-120A and 199-K-162) and in the K North plume area (e.g., wells 199-K-149 and 199-K-150).
- Treated water injections at wells 199-K-159, 199-K-160, and 199-K-164 are regarded as contributing to reductions in the extent of the K North plume area.
- The K North plume is unbounded around well 199-K-182 (Figure 3-5).

### **KW Reactor Area**

The KW Reactor area hexavalent chromium plume is located near the KW Reactor, supporting water treatment facilities, and associated waste sites (Figures 3-2 and 3-5). The KW Reactor area plume has been monitored since the early 1990s when many of the CERCLA monitoring wells were initially installed. The KW P&T system, consisting of four extraction wells and two injection wells, became operational in January 2007 to remediate this plume after elevated hexavalent chromium concentrations were detected in aquifer tube AT-K-1. Four wells drilled in 2008 detected high chromium concentrations, and three of the wells were later converted to extraction wells. The capacity of the KW P&T system was subsequently expanded from 380 to 760 L/min (100 to 200 gpm), with seven extraction wells and three injection wells comprising the well field. The expanded KW P&T system began operation in April 2009.

The hexavalent chromium concentrations obtained from wells and aquifer tubes for the KW Reactor area plume during CY 2010 are presented in Table 3-2. Data from CY 2008 and CY 2009 are included for comparison. The findings and observations based on the results presented in Table 3-2 are summarized below.

The highest concentrations in the plume are located in the upgradient section of the plume that generally extends from the reactor area to the former KW headhouse (Figure 3-5). In fall 2008, samples collected from monitoring well 199-K-137 (located just upgradient of the KW Reactor) and monitoring well 199-K-165 (located between approximately 31 and 61 m [100 and 200 ft] further upgradient) yielded hexavalent chromium concentrations of 1,390 and 2,530  $\mu\text{g/L}$ , respectively (Table 3-2), which are well above typical coolant water concentrations (approximately 700 to 170  $\mu\text{g/L}$ ). Well 199-K-165 was converted to an extraction well for the KW P&T system in early 2009 and, by fall 2010, the concentrations observed in extraction wells 199-K-137 and 199-K-165 had declined to 109 and 321  $\mu\text{g/L}$ , respectively (Table 3-2). Despite these decreases, the 321  $\mu\text{g/L}$  hexavalent chromium concentration observed in extraction well 199-K-165 was the highest value measured in the 100-KR-4 OU during the fall 2010 monitoring event. Limited monitoring data (not shown in Table 3-2) from monitoring wells 199-K-35 and 199-K-173 and recent groundwater profile data collected during RI/FS drilling

activities suggest that elevated hexavalent chromium concentrations (e.g., 500 µg/L) that define the core of the KW Reactor area plume may have originated from one or more vadose zone or groundwater source areas located near the former KW headhouse. Additional observations based on the results presented in Table 3-2 are as follows:

- Fall 2010 hexavalent chromium concentrations were less than 20 µg/L in 6 of 12 wells sampled.
- Hexavalent chromium concentrations decreased from 2008 to 2010 in 10 of 10 wells and decreased or were unchanged from 2009 to 2010 in 11 of 12 wells.
- Hexavalent chromium concentrations in downgradient extraction wells 199-K-132 and 199-K-138 have declined steadily to 16.8 and 20.6 µg/L, respectively.

### **KE Reactor Area**

The KE Reactor plume is currently being remediated by the KX P&T system. This plume has been intensively monitored since the early 1990s when several CERCLA monitoring wells were installed to characterize potential groundwater contamination in the area. It is the smallest hexavalent chromium plume in the 100-KR-4 OU and appears to be largely confined to the area near extraction wells 199-K-141 and 199-K-178, downgradient of the KE Reactor (Figure 3-5).

The source of this plume is believed to be a combination of localized spills or leaks of highly concentrated sodium dichromate associated with the KE Reactor water treatment facilities and the large plume created by mounding around the 116-K-2 Trench. None of the KE Reactor area wells have displayed very high hexavalent chromium concentrations that could be attributed to spilled concentrated sodium dichromate. Table 3-3 compares CY 2010 hexavalent chromium concentrations from wells and aquifer tubes to CY 2008 and CY 2009 concentrations. The table also includes 2008 to 2010 and 2009 to 2010 changes in concentration. Details from Table 3-3 are summarized below:

- Fall 2010 hexavalent chromium concentrations were less than 20 µg/L in 8 of 11 wells sampled.
- Hexavalent chromium concentrations were decreased or remain unchanged from 2008 to 2010 in 5 of 8 wells, and decreased in 5 of 11 wells from 2009 to 2010.
- The maximum decrease in hexavalent chromium concentration from 2008 to 2010 was 91 percent in extraction well 199-K-141 (from 421 to 38 µg/L). On one occasion in 2009 during which well 199-K-141 pumping stopped, hexavalent chromium concentrations rebounded from 66 to 209 µg/L in 4 months but returned to 66 µg/L 2 weeks after restart.
- The maximum increase in hexavalent chromium from 2008 to 2010 was 127.3 percent in well 199-K-30; however, the concentration during 2010 was 7.5 µg/L.
- The KE Reactor plume has apparently contracted due to pumping operations during 2010.
- A small plume is centered around well 199-K-36, located between the KE headhouse and the KE sedimentation basin.

These observations suggest minimal contribution from any continuing sources in the vadose zone. The new RI/FS work plan wells will help delineate horizontal and vertical stratification of hexavalent chromium and other contaminants in the confined aquifer.

### **3.2.2.2 Tritium**

Tritium is formed by neutron activation during reactor operations and by fission in fuel rods. It is associated with the 116-KE-1 and 116-KW-1 gas condensate cribs (to the northeast of the KE and

KW Reactors), as well as the KE and KW Reactors' fuel storage basins and the associated 116-KE-3 and 116-KW-2 Cribs. The 118-K-1 Burial Grounds also constitutes another tritium source.

The spring and fall CY 2010 tritium plume maps for the 100-KR-4 OU are presented in Figure 3-6. Separate small plumes are located near the KW and KE Reactor areas, and a larger plume is located near the 116-K-2 Trench area (Figure 3-6).

### **116-K-2 Trench Area**

The source of the tritium plume in the vicinity of the 116-K-2 Trench is likely the silos buried near the center of the 118-K-1 Burial Ground. The spring and fall CY 2010 tritium plume maps are presented in Figure 3-6. Tritium-bearing groundwater from wells 199-K-144, 199-K-145, 199-K-162, and 199-K-120A passes through the KR4 treatment system and is injected upgradient of the 116-K-2 Trench. The fall 2008, 2009, and 2010 sampling results are presented in Table 3-4 and the highlights are summarized below:

- Fall 2010 tritium concentrations were less than the 20,000 pCi/L DWS in 17 of 18 wells sampled.
- Tritium concentrations decreased or were unchanged from 2008 to 2010 in 6 of 10 wells, and from 2009 to 2010 in 12 of 13 wells.
- The maximum fall 2010 tritium concentration was 27,000 pCi/L in well 199-K-157; however, the tritium concentration has decreased 91.6 percent in this well since 2008 (320,000 pCi/L).
- The maximum increase in tritium concentration from 2008 to 2010 was from 203 pCi/L (nondetect) to 5,200 pCi/L in well 199-K-163. This well is located north of the KR4 P&T system injection field.
- Tritium-bearing water injected upgradient of the 116-K-2 Trench flows to monitoring and extraction wells downgradient of the trench. Since the start of P&T operations, tritium levels have steadily risen to concentrations of 7,500 to 8,300 pCi/L at wells 199-K-119A, 199-K-125A, and 199-K-127, which are located in the center third of the trench.

### **KW Reactor Area**

The source of the KW Reactor area plume is likely the 116-KW-1 gas condensate crib, located along the east side of the KW Reactor (Figure 3-6). Fall 2010 sampling results, as well as the 2008 and 2009 results, are summarized in Table 3-5, and highlights are as follows:

- Fall 2010 tritium concentrations were less than the 20,000 pCi/L DWS in all seven wells sampled.
- The maximum fall 2010 tritium concentration was 7,500 pCi/L in well 199-K-132.
- Tritium concentrations increased from 2008 to 2010 in six of seven wells, with a maximum decrease of 215.4 percent (to 4,100 pCi/L) in well 199-K-34.
- Well 199-K-106A was characterized by an 84.8 percent decrease in tritium concentration from 2008 to 2010 (from 21,000 pCi/L in 2008 to 3,200 pCi/L in 2010). Between 2001 and 2009, tritium concentrations at well 199-K-106A trended between 30,000 to 2,240,000 pCi/L, with only two detections below the 20,000 pCi/L DWS. Since April 2009, tritium concentrations have remained at or below 6,200 pCi/L.

### **KE Reactor Area**

The source of the KE Reactor area plume is likely the 116-KE-1 gas condensate crib, located on the east side of the KE Reactor (Figure 3-6). Results for fall 2010, 2009, and 2008 are summarized in Table 3-6 and highlights are presented below:

- Fall 2010 tritium concentrations were less than the 20,000 pCi/L DWS in seven of nine wells sampled.
- The maximum fall 2010 tritium concentration was 130,000 pCi/L in well 199-K-29. This result is being verified because it is much higher than the tritium concentration trend for the well.
- Well 199-K-30 was characterized by a 96.1 percent decrease in tritium concentration from 2008 to 2010 (to 16,000 pCi/L). This result is being verified because it is much less than the tritium concentration trend for the well.
- Well 199-K-111A displaying an increase for the period from 2008 to 2010, increasing 333.3 percent (6,000 pCi/L in 2008 and 26,000 pCi/L in 2010). It is possible the tritium detected in this well alternately may be from the 118-K-1 Burial Ground.

### 3.2.2.3 Strontium-90

Strontium-90 is a fission product associated with fuel rod failures during reactor operations or within fuel storage basins. The 116-K-2 Trench was intended to be the disposal site for cooling water contaminated by fuel rod failures, and it received cooling water associated with the 275 events at the KE and KE Reactors (PNWD-2161 HEDR, *Fuel Element Failures in Hanford Single Pass Reactors, 1947 to 1971*). Of the analytes discussed in Section 3.2.2, strontium-90 is the least mobile in soil and groundwater.

Strontium-90 in 100-KR-4 OU groundwater is also associated with discharges to the 116-KW-2 and 116-KE-3 fuel rod cribs during and after reactor operations (Figure 3-2). The DWS for strontium-90 is 8 pCi/L. The spring and fall 2010 strontium-90 distributions in the 100-KR-4 OU are shown in Figure 3-7. The following subsections describe the strontium-90 plumes around the 116-K-2 Trench, KW Reactor, and KE Reactor.

#### 116-K-2 Trench Area

The 116-K-2 Trench is the source of the strontium-90 contamination in this area. The strontium-90 monitoring data collected near the 116-K-2 Trench during the fall 2010 are presented in Table 3-7. The fall 2009 and 2008 data for the same monitoring locations are also presented for comparison purposes. Notable characteristics of the strontium-90 data presented in Table 3-7 are summarized below:

- Fall 2010 strontium-90 concentrations were less than the 8 pCi/L MCL in 15 of 18 wells sampled in the 116-K-2 Trench area.
- The maximum fall 2010 strontium-90 concentration was 17 pCi/L in well 199-K-21, which is located downgradient of the suspected source, the 116-K-2 Trench. However, strontium-90 decreased 36.3 percent from 2008 to 2010 at this well. The other eight wells sampled in both 2008 and 2010 were characterized by strontium-90 nondetects, and changes in concentration were not calculated.
- Well 199-K-200, a temporary well penetrating the southwestern end of the 116-K-2 Trench and drilled as part of the 100-K Area RI characterization, had strontium-90 concentrations detected in groundwater at 130 and 160 pCi/L in 2010. Downgradient RI well 199-K-192 had only one strontium-90 detection at the top of the aquifer at 19 pCi/L during vertical profile sampling. All other downgradient wells at this end of the trench have below DWS or nondetect concentrations.

**KW Reactor Area**

The source of the KW Reactor area strontium-90 plume is assumed to be the former KW Basin's 116-KW-2 Crib. The fall 2010 results, as well as the related 2008 and 2009 results, are presented in Table 3-8 and are summarized as follows:

- Fall strontium-90 concentrations were less than the 8 pCi/L MCL in four of six wells sampled in the KW Reactor area.
- The maximum fall strontium-90 concentration was 45 pCi/L in well 199-K-34.
- Strontium-90 increased from 36.4 pCi/L in 2008 to 45 pCi/L (nondetect) in 2010. The other two wells sampled in both 2008 and 2010 were characterized by strontium-90 nondetects in all samples, and changes in concentration were not calculated.
- Well 199-K-107A was characterized by an increase in strontium-90 from 13 pCi/L in 2009 to 14 pCi/L in 2010. The other wells sampled in both 2009 and 2010 were characterized by a decrease in strontium-90 concentration, or all the sample results nondetects for strontium-90 and changes were not calculated.

**KE Reactor Area**

The source of the small KE Reactor strontium-90 plume (Figure 3-7) is assumed to be the 116-KE-3 Crib. The fall 2010 results, as well as related 2008 and 2009 results, are presented in Table 3-9 and are summarized as follows:

- Fall 2010 strontium-90 concentrations were less than the 8 pCi/L MCL in all seven wells sampled in the KE Reactor area.
- The maximum strontium-90 concentration was 4.4 pCi/L in well 199-K-32A.
- The maximum strontium-90 decrease from 2009 to 2010 was 72.5 percent in well 199-K-32A. The fall 2009 result was 16 pCi/L, decreasing to 4.4 pCi/L in 2010.
- The maximum strontium-90 concentrations in the KE Reactor area have been in well 199-K-109A, which was characterized by a concentration of 1,120 pCi/L in 2008. Recent strontium-90 results are not available for this well.

**3.2.2.4 Carbon-14**

Carbon-14 in groundwater in the 100-KR-4 OU (Figure 3-8) likely originates from two major sources, which are the 116-KE-1 and 116-KW-1 gas condensate cribs. Carbon-14 was generated by circulating nitrogen gas through the neutron flux fields of the KE and KW Reactors. Nitrogen was substituted for a helium/carbon dioxide blanket gas around the reactor core in the early 1960s. The blanket gas served to help cool the reactor and remove water vapor. The gas was cooled at the 115-KE and 115-KW gas condensate facilities, and water vapor was discharged to the 116-KE-1 and 116-KW-1 gas condensate cribs, respectively.

Older wells around the 116-K-2 Trench have trends of detectable carbon-14 that are far below the 2,000 pCi/L DWS. Piping may have allowed for water contaminated with carbon-14 to be routed from the 115-KE and 115-KW gas condensate facilities to the 116-K-2 Trench, but it is not clear if the piping was ever used. Alternately, the minor carbon-14 contamination observed at the older wells could be the result of discharges to the 116-KE-1 Crib dispersing with groundwater flow and coming under the influence of extractive pumping at the KR4 and KX P&T systems. The 118-K-1 Burial Ground is also a suspected but unproven candidate source.

The following subsections describe the carbon-14 results for 2010 for the 116-K-2 Trench area, KW Reactor area, and KE Reactor area.

### **116-K-2 Trench Area**

The suspected source of the carbon-14 detected in wells around the 116-K-2 Trench is the 116-K-2 Trench. Recent maximum values near the 116-K-2 Trench have been between 16 to 30.2 pCi/L. The fall 2010 results, as well as the 2008 and 2009 results, are presented in Table 3-10 and are summarized as follows:

- Fall 2010 carbon-14 concentrations were significantly below the 2,000 pCi/L DWS in each of the 13 wells sampled.
- The maximum fall 2010 carbon-14 concentration was 21.5 pCi/L in well 199-K-18.
- Carbon-14 concentrations decreased or remained nondetect from 2008 to 2010 in 4 of 5 wells, and from 2009 to 2010 in 9 of 10 wells.

### **KW Reactor Area**

The suspected source of the carbon-14 detected in the wells around the KW Reactor is the 115-KW gas condensate facility and crib 116-KW-1. The fall 2010 results, as well as the 2008 and 2009 results, are presented in Table 3-11 and are summarized as follows:

- The maximum fall 2010 carbon-14 concentrations were 2,590 pCi/L in well 199-K-34 and 2,350 pCi/L in well 199-K-132. The fall 2010 carbon-14 concentrations were less than 400 pCi/L in the other three wells sampled. Carbon-14 concentrations decreased from 2008 to 2010 in two of five wells sampled and increased from 2009 to 2010 in four of five wells sampled.
- Well 199-K-106A reported a maximum carbon-14 concentration of 10,100 pCi/L in June 2010. The trend at this well reached to 39,600 pCi/L in 1997. The trend remained above 10,000 pCi/L between 1994 and 2007, except in 2001 when concentrations declined to 6,700 pCi/L and 7,600 pCi/L.
- At the KW P&T system, a small percentage of carbon-14 is removed by the Dowex-21K<sup>®</sup> resin. Sampling in December 2010 indicated carbon-14 concentrations of 700 pCi/L in the influent tank and 580 pCi/L in the effluent tank. Treated water is returned to the aquifer at injection wells 199-K-158, 199-K-174, and 199-K-175.
- Carbon-14 was an analyte in vertical profile sampling of the RI wells around the KW Reactor (199-K-183, 199-K-184, 199-K-185, and 199-K-195). Only well 199-K-185 had a carbon-14 detection above the 2,000 pCi/L DWS, reaching a concentration of 2,390 pCi/L in a sample collected near the top of the aquifer. Samples from well 199-K-184 reached a maximum of concentration of 1,640 pCi/L. Carbon-14 in wells 199-K-183 and 199-K-195 did not exceed 900 pCi/L. Well 199-K-185 was drilled to replace well 199-K-33, which was decommissioned in 2003. Carbon-14 at well 199-K-33 ranged from 6,300 to 16,000 pCi/L between 1992 and 2003.

### **KE Reactor Area**

The suspected sources of the carbon-14 detected in the wells around the KE Reactor are the 115-KE gas condensate facility and the 116-KE-1 Crib (Figure 3-8). The fall 2010 results, as well as the 2008 and 2009 results, are presented in Table 3-12 and are summarized as follows:

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<sup>®</sup> Dowex is a registered trademark of the Dow Chemical Company, Midland, Michigan.

- The maximum fall 2010 carbon-14 concentration was 4,110 pCi/L in well 199-K-30. The only other well displaying a carbon-14 concentration above the MCL was 199-K-29 at 3,120 pCi/L. These final values were on trend with historic values at the time the wells were decommissioned in early 2011.
- Carbon-14 concentrations in well 199-K-30 decreased 33 percent from 2008 to 2010, and 29.5 percent from 2009 to 2010. The fall 2008 concentration in this well was 6,130 pCi/L, decreasing to 4,110 pCi/L in 2010. Concentrations at well 199-K-29 increased by 12 percent over the spring 2008 value of 2,780 pCi/L.
- Fall 2010 carbon-14 concentrations were less than the 2,000 pCi/L DWS in six of eight wells sampled.
- The maximum carbon-14 increase from 2008 to 2010 was 23.6 percent in well 199-K-11; however, the fall 2010 carbon-14 concentration was only 131 pCi/L.

### **3.2.2.5 Nitrate**

Nitrate is present in most of the 100-KR-4 OU wells at below DWS concentrations (less than 45,000 µg/L) (Figure 3-9). The nitrate may be associated with Hanford Site reactor or water plant operations, decontamination activities, septic systems, or pre-Hanford agricultural practices. The following subsections describe the nitrate plumes around the 116-K-2 Trench area, KW Reactor area, and KW Reactor area.

#### **116-K-2 Trench Area**

The fall 2010 results, as well as the 2008 and 2009 results, are presented in Table 3-13 and are summarized as follows:

- The maximum fall 2010 nitrate concentration was 60,600 µg/L in well 199-K-18. This well declined by 8.1 percent from fall 2009 and by 17.0 percent from fall 2009, continuing a steady decrease that began in 1998.
- From 2008 to 2010, nitrate concentrations decreased in the five wells sampled in both years, with a maximum decrease of 68.1 percent in well 199-K-117A to 1,920 µg/L.
- Nitrate concentration decreased from 2009 to 2010 in 10 of 12 wells sampled in both years. The maximum decrease was 56 percent in well 199-K-117A.
- Nitrate increased a maximum of 37.6 percent from 2009 to 2010 in well 199-K-21 to 14,800 µg/L.

#### **KW Reactor Area**

The fall 2010 results, as well as the 2008 and 2009 results, are presented in Table 3-14 and are summarized as follows:

- Fall 2010 nitrate concentrations were less than the 45,000 µg/L DWS in six of seven wells sampled.
- The maximum fall 2010 nitrate concentration was 73,900 µg/L in well 199-K-106A.
- The maximum decrease in nitrate concentration from 2008 to 2010 was 88.4 percent in well 199-K-166, from 193,000 µg/L in 2008 to 22,400 µg/L in 2010.
- Nitrate increased from 2008 to 2010 in four of seven wells sampled in both years, with a maximum increase of 21.2 percent in well 199-K-132 to 34,300 µg/L.

### **KE Reactor Area**

The fall 2010 results, as well as the 2008 and 2009 results, are presented in Table 3-15, and are summarized as follows:

- Fall 2010 nitrate concentrations were less than the 45,000 µg/L DWS in eight of nine wells sampled.
- The maximum fall 2010 nitrate concentration was 46,500 µg/L in well 199-K-29. This was the only well sampled with nitrate concentrations above the DWS.
- Nitrate concentrations decreased from 2008 to 2010 in five of seven wells sampled in both years. The maximum decrease was 68.5 percent in well 199-K-30, from 79,700 µg/L in 2008 to 25,100 µg/L in 2010. The 2010 values for wells 199-K-29 and 199-K-30 appear to be off-trend. The maximum increase in nitrate concentration from 2008 to 2010 was 27.1 µg/L in well 199-K-36, from 22,100 µg/L in 2008 to 28,100 µg/L in 2010.

#### **3.2.2.6 Trichloroethene**

Trichloroethene (TCE) is a chlorinated solvent commonly used onsite as a degreasing or decontamination agent. The 100-KR-4 OU groundwater that is contaminated with TCE at concentrations above the 5 µg/L DWS is limited to the KW Reactor area. Available data collected during fall 2010, as well as the 2008 and 2009 TCE results from these locations, are presented in Table 3-16. Extraction well 199-K-132 (Figure 3-10) is the only location sampled during fall 2010 that exceeded the 5 µg/L DWS for TCE. Concentrations at this location were 6.2 µg/L in fall 2009 and 4.2 µg/L in fall 2008. Trends at well 199-K-106A and former well 199-K-33 suggest that the 116-KW-1 Crib may be the TCE source.

### **3.3 CERCLA Operable Unit Activities**

This section summarizes the activities related to the operation and performance monitoring of the KR4, KW, and the KX P&T systems during CY 2010. Specific activities and operational performance details for these system that are discussed include changes to system configuration, system availability, mass of contaminants removed during operation, contaminant removal efficiencies, quantity and quality of extracted and disposed groundwater, and waste generation.

The remedial performance of the KW, KR4, and KX P&T systems (i.e., extent and effectiveness of plume capture) was evaluated by (1) reviewing the changes in hexavalent chromium concentrations over time in selected monitoring and extraction wells associated with the KR4, KW, and KX well fields; and (2) using two different methods of capture zone analysis to estimate the extent of plume capture by the three P&T systems under CY 2010 operating conditions.

To appropriately evaluate the effectiveness of plume capture in the 100-KR-4 OU, it was necessary to evaluate the combined capture zones of the KR4, KW, and KX P&T systems (Figure 3-11[a] and [b]), as well as the effectiveness of the capture zones for each individual treatment system (Figure 3-12). An overview of the extent and effectiveness of the combined (OU-wide) capture zone is discussed below. Overviews of the capture zone distribution and the efficiency for each of the three treatment systems (KR4, KW, and the KX) are presented in Sections 3.3.1.3, 3.3.2.3, and 3.3.3.3, respectively. More detailed descriptions of the methods used and results of the capture zone evaluation are presented in Appendix C.

Figure 3-11(a) and (b) depicts independently calculated representations of the combined site-wide capture zone for the 100-KR-4 OU. The results shown in Figure 3-11(a) were based primarily on groundwater modeling analysis, while the results shown in Figure 3-11(b) are based on a deterministic approach that incorporates high-frequency mapping of nearly continuously data-logged water-level

measurements of the aquifer during several months of system operation (see Appendix C for details of both methods of capture zone analysis).

The data inputs and assumptions underlying these different methods of capture zone analysis are not the same, and the depictions of the extent and aggregate performance of the capture zones generated by these two methods are not identical. For example, the groundwater modeling approach (Figure 3-11[a]) depicts areas where current and future capture zone frequency/efficiency of the 100-KR-4 OU systems are based on the actual operating conditions of the systems during CY 2010, including periods when the systems were not operating (e.g., planned or unplanned system shutdown). This approach is useful for evaluating how periods of reduced extraction during the year would, if not remediated, reduce the long-term capture efficiency of the affected system. Conversely, Figure 3-11(b) presents those areas where current and future site-wide capture zone frequency/efficiency is based (with the exception of small-duration stoppages) only on the hydraulic conditions of the aquifer while the system was operating during CY 2010. This approach does not include the effects of long-term, nonroutine shutdown events that occurred during 2010 as a continuing aspect of future capture zone performance. Consequently, the capture zone performance illustrated in Figure 3-11(b) is a better representation of long-term capture zones effectiveness/efficiency of the treatments systems if it assumed that the currently proposed operating conditions will continue in the future.

A comparison of Figure 3-11(a) and (b) demonstrates many similarities and also some key differences in capture zone effectiveness that are obtained using these two different methods for the 100-KR-4 OU. Both approaches indicate that the northern and southern areas of the capture zone distributions have a capture efficiency of upgradient groundwater of between 80 and 100 percent. However, the groundwater model-based capture effectiveness/efficiency map (Figure 3-11[a]) suggests that the central area of the overall capture zone distribution (i.e., KR4 plume area) will capture the upgradient plume with an efficiency that is much lower (e.g., 50 to 70 percent) than predicted in Figure 3-11(b). This difference primarily reflects that the modeling-based analysis treats the reduced annual average extraction rates in this area during CY 2010 (due to the planned 3-month shutdown at the KR4 system) as the standard operating conditions over the full multi-year simulation period. Consequently, the substantially higher overall capture efficiencies (i.e., 80 to 100 percent) for the composite capture zone presented in Figure 3-11(b) are believed to represent a more realistic estimate of the capture efficiency of the overall system under the currently proposed operating conditions.

### 3.3.1 KR4 Pump-and-Treat System

The KR4 P&T system was designed to capture and treat the hexavalent chromium plume associated with the 116-K-2 Trench (Figure 3-2). Since startup in 1997, this system has treated over  $2.13 \times 10^{10}$  L (5.64 billion gal) of water and has removed 357.7 kg of hexavalent chromium. Over time, the KR4 system has remediated much of the plume originally present along the central portion of the 116-K-2 Trench to less than 20  $\mu\text{g/L}$  (Figure 3-5 and Appendix B). However, substantial areas of contamination remain in the groundwater at either end of the trench (i.e., KR4 and K North plumes). This may be attributed to the lower hydraulic conductivity values affecting movement in the aquifer at either end of the 116-K-2 Trench, the impact of increased hydraulic gradient from groundwater mounding at the injection wells acting cross-gradient on the plume, or a combined effect. The substantial reduction in the mass of contamination near the central section of the 116-K-2 Trench area since system startup appears to be mirrored by a gradual decline in the average treatment efficiency of the system (Figure 3-13). This reduction in removal efficiency is consistent with the generally decreasing average influent hexavalent chromium concentrations that have occurred since system startup.

### 3.3.1.1 *KR4 Pump-and-Treat System Configuration and Changes*

The KR4 P&T system (Figure 3-14) was designed to receive and process up to 1,135.6 L/min (300 gpm). The current system design includes 10 extraction wells (199-K-113A, 199-K-114A, 199-K-115A, 199-K-116A, 199-K-120A, 199-K-127, 199-K-129, 199-K-144, 199-K-145, and 199-K-162), and five injection wells (199-K-121A, 199-K-122A, 199-K-123A, 199-K-128, and 199-K-179) (Figure 3-2). Three of the extraction wells (199-K-144, 199-K-145, and 199-K-162) were originally connected to the KX P&T system; these three wells were realigned and connected to the KR4 system in 2009 and were put into service as KR4 system extraction wells in February 2010. Realignment of these wells as KR4 extraction wells was implemented to better limit the extent of a tritium plume migrating toward these extraction wells from the vicinity of the 118-K-1 Burial Grounds. Although neither the KR4 nor the KW IX treatment system will remove tritium from the extracted water, the reinjection well system for the KR4 system restricts the injection of tritium-contaminated, treated effluent to a relatively small area. The injected water is partially extracted and recirculated back to the KR4 system, thereby reducing further spread of tritium. Tritium trends at monitoring wells 199-K-119A and 199-K-125A and extraction well 199-K-127) downgradient of the central half of the 116-K-2 Trench increased to concentrations of 7,500 to 8,300 pCi/L by 2010. The tritium trends for two of the three wells began to decline in 2009 and 2010.

### 3.3.1.2 *KR4 Pump-and-Treat System Performance*

Table 3-17 presents an overview of the operational parameters and total system performance for the KR4 P&T system during CY 2010. During CY 2010, the system processed groundwater at an average annual pumping rate of approximately 641 L/min (169 gpm). However, as previously noted, the KR4 P&T system was out of service for most of October, all of November, and all of December 2010 (Figure 3-15). Consequently, the reported annualized pumping rate is somewhat lower than the average rate of approximately 855 L/min (226 gpm) achieved when the system was operating. The hexavalent chromium concentrations in the influent of the KR4 system gradually declined from approximately 30 µg/L in January to approximately 20 µg/L in October (Figure 3-16), averaging 23 µg/L for the year.

The maximum hexavalent chromium concentration observed in the effluent of the KR4 system during CY 2010 was 7 µg/L and the average concentration was 2 µg/L. Additional operational and system characteristics of the KR4 P&T system for CY 2010 are summarized as follows:

- A total of 336.9 million L (89 million gal) of groundwater were treated and approximately 7.2 kg of hexavalent chromium were removed.
- The mass removal efficiency for CY 2010 was 90.6 percent, which is somewhat higher than 86.9 percent reported in CY 2009 (Table 3-17).
- Total system availability for CY 2010 was 75.2 percent, substantially lower than the 86.9 percent total availability reported in CY 2009. The lower total availability is largely due to the planned shutdown of the KR4 P&T system on October 5, 2010, when the system was taken offline for system upgrades. The system was restarted on January 13, 2011.
- The scheduled system availability for CY 2010 (January 1 through October 5) was 99.6 percent,
- Resin changeouts were performed on 20 vessels in CY 2010. No new resin was installed in CY 2010, and regenerated resin totaled 54.4 m<sup>3</sup> (1,921 ft<sup>3</sup>).

Table 3-18 presents the pumping flow rates and total run-time (total flow hours ÷ total possible run-time) for each extraction well currently at use in the KR4 P&T system. Except where noted, the recommended flow rates are based on updated numerical modeling results that were prepared to support the CERCLA

5-year review design modification. The average flow rate during CY 2010 was calculated by dividing the total volume extracted by the hours in a year.

A comparison of the recommended and actual extraction rates indicates that wells 199-K-113A, 199-K-114A, and 199-K-129 were pumped at lower flow rates during the year than recommended. These lower flow rates were implemented primarily to prevent additional dilution of the already low hexavalent chromium concentrations being captured by these wells. Other extraction wells at the KR4 P&T system were operated at extraction rates that were very close to the recommended flow rates.

During CY 2010, all wells were subject to downtime due to area power-grid outages, equipment failures, and/or maintenance. The downtime is reflected in the yearly average flow rate calculations and the total run-time percentages for each extraction well. The KR4 P&T system was taken offline on October 5, 2010, for maintenance and system upgrades and was placed back into service early in CY 2011. Wells 199-K-113A and 199-K-114A were shut down for most of July and August due to low hexavalent chromium concentrations during a period when high river stage impacted these two near-shore extraction wells.

After 13 years of successful treatment, declining influent concentrations at the KR4 system are beginning to reduce the efficiency of the IX process. Average annual influent concentrations are noted as decreasing over time since 1997 (Figure 3-17). When hexavalent chromium concentrations in the groundwater influent are low, the hexavalent chromium already on the resins may be eluted off because of the higher affinity to higher phosphate and sulfate concentrations present in the groundwater, thus reducing or negating the gains of chromium captured by the resins. This "tailing effect" is unavoidable in a mature system unless new sources of contaminants are identified. Within the bounds of the KR4 plume, only a few of the original extraction wells are capable of producing hexavalent chromium concentrations above the 20 µg/L cleanup standard. Given the decreasing size of the residual KR4 plumes and the current extraction well coverage in those areas, prospects for improving the treatment efficiency of the KR4 system include hooking up new and/or active KX system wells to the KR4 system well field.

### **3.3.1.3 Capture Zone Analysis**

Figure 3-12(a) illustrates the composite capture zone produced by the KR4 P&T system well field. The extent and projected capture efficiency of the KR4 composite capture zone were developed based on high-frequency mapping of the water table levels at the site during operation of the system in CY 2010 (see Appendix C for details on methods). The predicted capture efficiency for groundwater contaminants within and upgradient of the KR4 extraction well field ranges between 90 and 100 percent. The extent and the high predicted capture efficiencies of the KR4 system's capture zone are consistent with the observed remediation of the hexavalent chromium plume in the central area of the 116-K-2 Trench.

### **3.3.1.4 KR4 Pump-and-Treat System Compliance Monitoring**

The remedial performance of the KR4 P&T systems (i.e., extent and effectiveness of plume capture) has been evaluated using hexavalent chromium data from selected monitoring locations including, but not limited to, compliance monitoring wells 199-K-20 and 199-K-117A and active extraction/compliance wells 199-K-114A and 199-K-129 (DOE/RL-2006-75, *Supplement to the 100-HR-3 and 100-KR-4 Remedial Design Report and Remedial Action Workplan for the Expansion of the 100-KR-4 Pump-and-Treat System*). (Note that well 199-K-18 has been dropped as a compliance well because extraction and Phase 3 RPO wells are now located downgradient.) The general effectiveness of the KR4 system in the central section of the 116-K-2 Trench area is evident by the long-term decreasing concentration trends of hexavalent chromium in compliance monitoring wells 199-K-117A, 199-K-21, and 199-K-20. The hexavalent chromium concentrations in each of these three monitoring wells have averaged below 10 µg/L since 2008 (Figure 3-18). In addition, the concentrations in extraction

wells 199-K-125A and 199-K-119A have steadily decreased, from about 40 µg/L in 2004 to below the detection limit (less than 2 µg/L) by January 2010 (Figure 3-18 and Table 3-1).

The KR4 extraction/compliance well 199-K-114A and nearby extraction well 199-K-113A are located downgradient of the northeast section of the 116-K-2 Trench and near the river in the K North plume (Figure 3-18). The pronounced sawtooth pattern is evident in the long-term hexavalent chromium concentration trends in these extraction wells and indicates that hexavalent chromium concentrations in groundwater near the shoreline are attenuated by mixing with river water during the spring when river stage is high (Figure 3-18). Both wells appeared to show a subtle decrease in hexavalent chromium concentrations in groundwater samples collected during the summer to early fall 2010 (when the river stage was lower) relative to previous years. Concentrations in both wells remained below 10 µg/L during low river stage when hexavalent chromium concentrations in near-shore plume wells are generally highest.

The KR4 extraction/compliance well 199-K-129 is also located near the river in the central area of the K North plume but is somewhat further to the north than wells 199-K-114A and 199-K-113A (Figure 3-18). The long-term concentration trend in extraction well 199-K-129 shows a more subdued seasonal sawtooth pattern, and hexavalent chromium concentrations have gradually decreased from a high of about 60 µg/L in early 2004 to a low of 10 to 20 µg/L in late 2010 (Figure 3-18). The concentrations observed in this well in mid- to late 2010 are consistent with the observed lower concentrations and inferred decreased mass of the plume in this area. If the decreasing concentration trends observed throughout CY 2010 for KR4 extraction wells 199-K-114A, 199-K-113A, and 199-K-129 continue into the fall of 2011, this may signify achievement of the interim action objective of protecting the river along this section of the K North plume (Figures 3-4 and 3-18).

Compliance well 199-K-18 is located in the KR4 plume, in the vicinity of the southern end of the 116-K-2 Trench (Figures 3-4 and 3-18). The hexavalent chromium concentrations in this well steadily increased from approximately 140 µg/L in 2004 to approximately 200 µg/L by April 2010 (Figure 3-16). However, the concentrations in this well declined steadily during the remainder of 2010, reaching a concentration of 139 µg/L by December 2010 (Table 3-1 and Figure 3-18). Concentrations have continued declining in 2011. The reversal in the long-term increasing concentration trend for hexavalent chromium in this well likely reflects the February 2010 startup of three nearby KR4 extraction wells (199-K-162, 199-K-145, and 199-K-120A). Of these three new extraction wells, the hexavalent chromium concentrations in water sampled at well 199-K-145 averaged approximately 60 µg/L during CY 2010, which is substantially higher than concentrations extracted by wells 199-K-162 and 199-K-120A. In these latter two wells, concentrations decreased below 10 µg/L soon after startup (Figure 3-18). Injection of treated effluent at KX system well 199-K-156 (active since February 2009) may also be a factor affecting the decreasing concentrations at these two wells.

Although aquifer tubes are not official compliance points for treatment system performance, samples collected from these tubes are helpful for locating areas where hexavalent chromium may be discharging to the Columbia River at concentrations greater than 20 µg/L. Aquifer tube AT-K-3-D is located downgradient of monitoring well 199-K-18 and new extraction wells 199-K-162, 199-K-145, and 199-K-120A. This aquifer tube has had concentrations ranging from approximately 32 to 85 µg/L since first sampled in 2004 (Figure 3-18); the December 2010 results were near the middle of that range. Given the recent startup of upgradient extraction wells 199-K-162, 199-K-145, and 199-K-120A, as well as the abrupt decreased concentrations in monitoring well 199-K-18 during CY 2010 (see discussion above), the hexavalent chromium concentrations reaching this aquifer tube (and, therefore, the Columbia River) are expected to decrease substantially in this section of the KR4 plume within the next 1 to 2 years.

### 3.3.2 KW Pump-and-Treat System

The KW P&T system became operational on January 29, 2007, and since that time has treated over  $3.97 \times 10^9$  L (1.05 billion gal) of groundwater and removed 137.4 kg of hexavalent chromium. This P&T system was installed to address additional hexavalent chromium contamination discovered near the KW Reactor (Figure 3-4).

#### 3.3.2.1 KW Pump-and-Treat System Configuration and Changes

The KW P&T system (Figure 3-19) was originally designed to receive and process up to 378.5 L/min (100 gpm). System upgrades in CY 2009 expanded the treatment capacity to 757 L/min (200 gpm). The system is currently processing at an average annual pumping rate of approximately 738 L/min (195 gpm).

The KW system currently consists of seven extraction wells (199-K-132, 199-K-137, 199-K-138, 199-K-139, 199-K-165, 199-K-166, and 199-K-168), three injection wells (199-K-158, 199-K-174, and 199-K-175), and an IX treatment system similar in design to that used in the 100-KR-4 and 100-HR-3 OUs. On April 8, 2010, former extraction well 199-K-139 (taken offline in April 2009) replaced well 199-K-140 as a nearby extraction well to 199-K-168. Chromium concentrations in well 199-K-140 had declined to less than 10  $\mu\text{g/L}$ . Well 199-K-140 was disconnected in April 2010 but remains available for restart if needed.

#### 3.3.2.2 KW Pump-and-Treat System Performance

Table 3-19 presents an overview of the operational parameters and total system performance for the KW P&T system during CY 2010. During CY 2010, the KW system processed groundwater at an average annual pumping rate of approximately 738 L/min (195 gpm) and operated at or near 100 percent of the scheduled availability during each month of the year (Figure 3-20). The average influent hexavalent chromium concentration for CY 2010 was 145.5  $\mu\text{g/L}$ , which is slightly less than the average concentration of 155.4  $\mu\text{g/L}$  reported for CY 2009.

Clear trends are evident in the influent concentrations during CY 2010. The hexavalent chromium concentrations in the influent of the KW system during CY 2010 gradually increased from approximately 125  $\mu\text{g/L}$  in January to 203  $\mu\text{g/L}$  in April (Figure 3-21). Influent concentrations declined 120  $\mu\text{g/L}$  by July. The beginning of relatively abrupt decline in influent concentrations corresponds with the restart of extraction well 199-K-139 in April and an increasing springtime river stage. Influent concentrations gradually increased from about 120  $\mu\text{g/L}$  in July to about 150  $\mu\text{g/L}$  by mid- to late September, generally coincident with declining river levels. From late September to the end of December, the influent concentrations gradually decreased to 112  $\mu\text{g/L}$ .

Concentrations in KW P&T system effluent remained consistently below 10  $\mu\text{g/L}$  during the entire operating period and gradually decreased as the year progressed (Figure 3-21). The average hexavalent concentration in the effluent during CY 2010 was 4.6  $\mu\text{g/L}$ , slightly higher the average effluent concentration of 4.2  $\mu\text{g/L}$  reported for CY 2009. Selected operational and system characteristics of the KW P&T system for CY 2010 are summarized below:

- The scheduled system availability for CY 2010 was 99.7 percent, slightly higher than the 98.6 percent reported in CY 2009. The total availability was 99.6 percent, which was slightly higher than the online availability of 95.6 percent reported in CY 2009. The monthly online percentages and the method used to calculate availability and online percentage for the reporting period are shown in Figure 3-20.

- A total of 387.15 million L (102.27 million gal) of groundwater was treated and approximately 54.14 kg of hexavalent chromium were removed.
- The mass removal efficiency for CY 2010 was 96.9 percent, slightly higher than in CY 2009 (95.8 percent) but lower than in 2007 and 2008 (Figure 3-22).

Table 3-20 presents the pumping flow rates and total run-time for the extraction and injection wells currently active in the KW P&T system. Except where noted, the recommended flow rates are based on updated numerical modeling results that were prepared to support the CERCLA 5-year review design modification. The average flow rate during CY 2010 was calculated by dividing the total volume extracted by the total hours in a year. All of the wells were subject to downtime because of area power-grid outages, equipment failures, and/or maintenance. This downtime is reflected in the yearly average flow rate calculations and the total run-time percentages for the individual extraction wells.

### **3.3.2.3 KW Pump-and-Treat System Capture Zone Analysis**

Figure 3-12(c) illustrates the composite capture zone produced by the KW P&T system well field. The extent and projected capture efficiency of the composite KW system capture zone was developed using high-frequency mapping of the water table during actual CY 2010 operating conditions. For CY 2010, the KW hexavalent chromium plume was located entirely within the part of the KW system capture predicted to have capture efficiencies between 90 and 100 percent. The extent and capture efficiency of the KW system composite capture zone is consistent with effective the remediation of the KW Reactor area plume (as currently defined) and the achievement of interim groundwater RAOs.

### **3.3.2.4 KW Pump-and-Treat System Compliance Monitoring**

The remedial performance of the KW P&T system has been evaluated using the 2008 to 2010 hexavalent chromium data presented in Table 3-3 and the long-term concentration trends for selected KW system monitoring locations (Figure 3-23).

Extraction/compliance wells 199-K-132 and 199-K-138 are located downgradient of the KW Reactor, near the leading edge of the KW Reactor area plume (Figure 3-4). Chromium concentrations at wells 199-K-132 and 199-K-138 were approximately 120 and 75  $\mu\text{g/L}$ , respectively, in January 2007 (Figure 3-23). Since startup of the KW P&T system, the concentrations in these wells have steadily declined. The measured concentrations in these wells during November 2010 were 16.8 and 20.6  $\mu\text{g/L}$ , respectively (Table 3-3).

Although data from a single aquifer tube location are not definitive, the long-term trend for aquifer tube AT-K-1-D (Figure 3-23) is consistent with the current interpretation that the leading edge of the KW Reactor area plume is being captured by the two downgradient extraction wells. Hexavalent chromium concentrations above 10 to 20  $\mu\text{g/L}$  are not reaching the Columbia River in the KW Reactor area (Figure 3-4). The concentrations in upgradient extraction wells 199-K-168, 199-K-139, 199-K-137, and 199-K-166 have all generally declined substantially over time (Figure 3-23). The exception is well 199-K-165, where concentrations increased moderately but steadily between mid-2009 and mid-2010, before again slowly declining.

## **3.3.3 KX Pump-and-Treat System**

The KX P&T system (Figure 3-24) was designed to receive and process groundwater at a rate of up to 2,300 L/min (600 gpm). This system was primarily designed to treat the K North hexavalent chromium plume located between the northern end of the 116-K-2 Trench and the N Reactor fence line. A small plume downgradient of the KE Reactor is also being treated by the KX system. The KX system began partial operation in November 2008 and became fully operational in early February 2009. The system is

currently processing at an average annual pumping rate of approximately 1,720 L/min (455 gpm). Since startup, the system has treated more than 1.5 billion L (412 million gal) of water and removed approximately 77.6 kg of hexavalent chromium.

### **3.3.3.1 KX Pump-and-Treat System Configuration and Changes**

The KX P&T system currently includes 12 extraction wells (199-K-130, 199-K-131, 199-K-141, 199-K-146, 199-K-147, 199-K-148, 199-K-153, 199-K-154, 199-K-161, 199-K-163, 199-K-171, and 199-K-178) and 9 injection wells (199-K-143, 199-K-156, 199-K-159, 199-K-160, 199-K-164, 199-K-169, 199-K-170, 199-K-172, and 199-K-180) (Figure 3-4). Two of these extraction wells (199-K-153 and 199-K-171) were converted from monitoring wells in mid-March 2010. Two wells that previously served as extraction wells (199-K-149 and 199-K-150) were taken out of service in June 2010 and will be used as monitoring wells. New extraction well 199-K-178 and new injection well 199-K-180 were put into service in mid-March 2010.

### **3.3.3.2 KX Pump-and-Treat System Performance**

Table 3-21 presents an overview of the operational parameters and total system performance for the KX P&T system during CY 2010. During CY 2010, the KX system processed groundwater at an average pumping rate of approximately 1,750 L/min (463 gpm). With the exception of February, March, and September 2010, the system operated nearly 100 percent of the time (Figure 3-25). The reduction in KX system availability during February and March occurred as a result of modification made to the extraction well system.

The average influent hexavalent chromium concentration for CY 2010 was 47.6 µg/L, which is approximately 20 percent less than the average concentration of 58.4 µg/L reported for CY 2009. Prior to the addition of extraction wells 199-K-153 and 199-K-171 to the system in mid-March, the influent concentrations averaged approximately 55 to 60 µg/L (Figure 3-26). After system modifications, the influent concentrations gradually decreased, generally ranging between 40 and 50 µg/L from June to December 2010.

The maximum reported concentration of hexavalent chromium in the effluent during CY 2010 was 8 µg/L. The average effluent concentration for the year was 2.8 µg/L, which is higher than the average effluent concentration of 2.1 µg/L reported for CY 2009. Additional operational and system parameters for the KX P&T system for CY 2010 are listed below:

- A total of 904.47 million L (238.93 million gal) of groundwater was treated in CY 2010 and approximately 39.82 kg of hexavalent chromium were removed.
- The mass removal efficiency for CY 2010 was 94.0 percent, which is slightly lower than the mass removal efficiency reported for CY 2009 (96.3 percent) (Figure 3-27).
- The scheduled system availability for CY 2010 was 99.2 percent, which is slightly higher than the system availability of 98.1 percent reported in CY 2009. The total availability was 99.2 percent, which was slightly higher than the online availability of 94.5 percent reported in CY 2009.

Table 3-22 presents the pumping flow rates and total run-time for the extraction wells currently active in the KX P&T system. Except where noted, the recommended flow rates are based on updated numerical modeling results that were prepared to support the CERCLA 5-year review design modification. The average flow rate during CY 2010 was calculated by dividing the total volume extracted by the total hours in a year. All of the wells were subject to downtime because of area power-grid outages, equipment failures, and/or maintenance. This downtime is reflected in the yearly average flow rate calculations and the total run-time percentages for the individual extraction well.

### 3.3.3.3 *KX Pump-and-Treat System Capture Zone Analysis*

Figure 3-12(b) illustrates the composite capture zone produced by the KX P&T system well field. The extent and projected capture efficiency of the composite KX system capture zone were developed using high-frequency mapping of the water table during the CY 2010 operating conditions. The KX hexavalent chromium plume for CY 2010 was located entirely within that part of the KX system capture predicted to have capture efficiencies between 90 and 100 percent. The extent and capture efficiency of the KX system composite capture zone under currently proposed operating conditions is consistent with the effective remediation of the K North plume (as currently defined) and the achievement of interim groundwater RAOs. A slight reduction in capture zone efficiency to 80 to 90 percent is noted for the small KE plume.

### 3.3.3.4 *KX Pump-and-Treat System Compliance Monitoring*

The remedial performance of the KX P&T system has been evaluated using the 2008 through 2010 hexavalent chromium data presented in Table 3-1 and long-term concentration trend plots for the 17 extraction wells for the KX P&T system and associated monitoring wells, including compliance monitoring/extraction wells 199-K-130, 199-K-131, 199-K-146, 199-K-147, 199-K-148, 199-K-149, 199-K-150, and 199-K-161 (Figure 3-28).

The majority of the KX system extraction wells are currently used to capture and remediate the plume area between the northern end of the 116-K-2 Trench and the N Reactor fence line (i.e., K North plume). Former extraction wells 199-K-150 and 199-K-149 were most northeastern extraction wells in the KX system well field (Figures 3-5 and 3-28). Hexavalent chromium concentrations in these wells have decreased from approximately 80 µg/L in late 2008 to 2 and 8 µg/L, respectively, in fall 2010. The decrease in concentrations observed in both wells likely reflects upgradient aquifer cleanup, as well as partial capture and recirculation of treated effluent from injection wells 199-K-159 and 199-K-160 (located 150 to 200 m [492 to 656 ft] cross-gradient to the northeast) and possibly from injection well 199-K-164 (located 430 m [1,411 ft] upgradient) (Figure 3-5). The hexavalent chromium concentrations obtained for fall 2010 in extraction wells 199-K-150 and 199-K-149 bound the northern boundary of the northeastern lobe of the K North plume.

Extraction wells 199-K-131, 199-K-148, 199-K-130, and 199-K-147 are located progressively further to the southwest. These well locations extend across the northeastern plume lobe of the K North plume, approximately 152 to 183 m (500 to 600 ft) upgradient from, and roughly parallel to, the Columbia River shoreline (Figure 3-28). The concentrations in these wells have steadily decreased since system startup but still retain concentrations above 30 µg/L. Upgradient monitoring wells 199-K-152 and 199-K-151 have demonstrated very different concentration trends since startup of the KX P&T system. Monitoring well 199-K-152 is located in the core of the northeastern plume lobe. The concentrations in this well have steadily declined from approximately 80 µg/L in mid-2008 to approximately 60 µg/L in late 2010 (Table 3-1 and Figure 3-28). Monitoring well 199-K-151 is located 230 m (755 ft) northeast/cross-gradient of monitoring well 199-K-152; in September 2008, prior to system startup, the concentration of hexavalent chromium in this well was 75.5 µg/L. When the KX system was started up, the concentrations in monitoring well 199-K-151 rapidly declined, reaching approximately 20 µg/L by early 2009. Concentrations continued to decline and, by fall 2010, the hexavalent chromium concentration in this well was 7.9 µg/L. Monitoring well 199-K-151 currently defines the northern upgradient extent of the K North plume.

Chromium concentrations at well 199-K-182, the farthest upgradient of wells in this plume segment, ranged between 74 and 81 µg/L in CY 2010. The plume is unbounded upgradient and cross-gradient of this well. A new 100-N Area well that will be drilled as part of RI characterization will be located

approximately 200 m (656 ft) northeast of this well and will provide an indication of lateral extent of the unbounded chromium plume.

The concentration trends described above for extraction wells 199-K-131, 199-K-148, 199-K-130, and 199-K-147, as well as for the monitoring wells, suggest that injection of large volumes of treated effluent in injection wells 199-K-159, 199-K-160, and 199-K-164 (Figure 3-5) has shifted the northeastern lobe of the K North plume further to the southwest. The potential to further optimize remediation of the northeastern plume lobe by modifying the amount of groundwater injected (either more or less) into wells 199-K-159, 199-K-160, and 199-K-164 should be evaluated. For example, it is possible that the injection of less water into wells 199-K-159, 199-K-160, and 199-K-164 may optimize this process and is being evaluated. Other KX system extraction wells 199-K-146, 199-K-161, 199-K-153, 199-K-154, and 199-K-163 are located in the southwestern plume lobe of the K North plume (Figure 3-28). Extraction wells 199-K-146 and 199-K-161 are closer to the river than wells 199-K-153, 199-K-154, and 199-K-163. Between the fall of 2009 and 2010, the hexavalent chromium concentrations in these two wells decreased from 44.8 to 21  $\mu\text{g/L}$  and from 85.9 to 14.1  $\mu\text{g/L}$ , respectively. In conjunction with nearby KR4 system extraction wells 199-K-114A and 199-K-113A, these two downgradient KX system extraction wells appear to have reduced hexavalent chromium concentrations near the river in this area to below 10  $\mu\text{g/L}$  (Figure 3-5). The concentrations in extraction wells 199-K-154 and 199-K-163 were above 100  $\mu\text{g/L}$  in late 2008. Since system startup, however, concentrations in wells 199-K-154 and 199-K-163 have declined to 85.2 and 52.2  $\mu\text{g/L}$ , respectively, by fall 2010. The relatively slow decline of the concentrations in these extraction wells suggests that a considerable mass of hexavalent chromium remains upgradient of these wells.

Monitoring wells 199-K-22 and 199-K-37 are located between upgradient extraction wells 199-K-154 and 199-K-163 and downgradient extraction wells 199-K-146 and 199-K-161. The hexavalent chromium concentrations in well 199-K-22 have decreased little since 2004, with concentrations remaining near 120  $\mu\text{g/L}$ . Evidence is currently not available to determine whether the contaminant levels in this well are being reduced by the upgradient extraction wells. At monitoring well 199-K-37, cross-gradient of the high-concentration area defined by monitoring well 199-K-22, concentrations were approximately 80  $\mu\text{g/L}$  in 2004 and declined very little until mid-2009. Perhaps as a result of the startup of the KX extraction system, concentrations decreased relatively quickly beginning in mid-2009, reaching 27.1  $\mu\text{g/L}$  in late 2010. If this trend continues, the remediated area located downgradient may soon extend upgradient to the vicinity of monitoring well 199-K-37.

Two KX system extraction wells, 199-K-178 and 199-K-141, are operating in the area of the KE Reactor area plume. Extraction well 199-K-178 was installed relatively recently, and all available data were collected after 2008. The concentrations in this well decreased to 23.8  $\mu\text{g/L}$  by fall 2010. Data for well 199-K-141 (as a monitoring well) are available as far back as 2007, and a high value of approximately 450  $\mu\text{g/L}$  was noted in January 2009 (Figure 3-28). After KX P&T system startup, the hexavalent chromium concentrations in this new extraction well decreased rapidly to 38  $\mu\text{g/L}$  by fall 2010.

### **3.4 Summary of Remedial Process Optimization and Remedial Investigation/ Feasibility Study Activities and Results**

The highlights of the RI/FS characterization activity conducted at the 100-KR-4 OU during CY 2010 are as follows:

- The highest hexavalent chromium concentrations were found at well 199-K-195, where a 3 m (10 ft) thickness of aquifer detected hexavalent chromium concentrations at 1,900 to 4,900 µg/L in the upper aquifer and at 753 µg/L at one zone in the deep unconfined aquifer, with intermediate zones of nondetected hexavalent chromium.
- The hexavalent chromium concentrations found near the bottom of the unconfined aquifer were less than 40 µg/L.
- Hexavalent chromium concentrations above the 48 µg/L MTCA standard were detected at wells 199-K-184 and 199-K-192. During a sampling event in early 2011, temporary well 199-K-201 encountered hexavalent chromium at concentrations above 100 µg/L.
- One of four wells drilled 15.2 m (50 ft) into the RUM encountered a water-bearing zone, with mostly nondetects for contaminants of interest.
- Tritium was encountered at concentrations of 36,000 to 1.4 million pCi/L in the upper 12.2 m (40 ft) of the aquifer at well 199-K-192. At well 199-K-189, tritium concentrations of 86,000 to 140,000 pCi/L were found within the upper 7.6 m (25 ft) of the aquifer. All other wells were below the 20,000 pCi/L DWS.
- Carbon-14 was found at well 199-K-185 at concentrations of 1,600 to 2,400 pCi/L in the upper 6.1 m (20 ft) of the aquifer. Where present at concentrations approaching 50 percent of the 2,000 pCi/L DWS, carbon-14 was found in the upper half of the aquifer.
- Strontium-90 was found in the aquifer above the 8 pCi/L DWS at well 199-K-192 (19 pCi/L) and was detected in well 199-K-189 (4.1 pCi/L) at the top of the aquifer.
- Nitrate above the 45,000 µg/L DWS was found at wells 199-K-185 (116,000 µg/L maximum), 199-K-190 (54,000 µg/L), 199-K-191 (76,600 µg/L), and 199-K-192 (56,200 µg/L). Concentrations were the highest across the upper aquifer in all wells and diminished with depth at many wells.
- TCE is found primarily at wells associated with the KW Reactor area. Wells 199-K-184 (8.1 µg/L) and 199-K-185 (6.5 µg/L) exceeded the 5 µg/L DWS, and TCE was detected in most sample intervals at these two wells. TCE is present at concentrations below DWS in wells 199-K-183, 199-K-186 (at the bottom of the aquifer), 199-K-188 (one detection at 1.5 µg/L), 199-K-190 (up to 1.6 µg/L), and 199-K-195 (several detections, up to 3.7 µg/L).
- Chloroform was found at wells 199-K-186 (1.9 µg/L), 199-K-188 (1.8 µg/L), 199-K-189 (1.2 µg/L) and 199-K-190 (2.2 µg/L). The concentrations are well below the 80 µg/L DWS for chloroform.
- After March 2011, the RI/FS wells will be sampled on a quarterly basis following quality assurance acceptance and clearance of maintenance and industrial health checks.
- Chloroform has been reported at concentrations well below the 80 µg/L DWS but at levels of interest to preliminary results from the RI/FS risk assessment process. One remote well, 199-K-151, had a concentration of 7.1 µg/L in September 2010; a waste site source is not known for this well. Chloroform at concentrations between 1 and 2 µg/L was reported at wells 199-K-11, 199-K-18, and 199-K-32A; no common waste site fits this well distribution.
- Total petroleum hydrocarbons (TPH) (diesel, gasoline, and kerosene) have been found in the vadose zone at wells 199-K-167 and 199-K-173 and at RI/FS well 199-K-188 near the 166-KW and 166-KE fuel storage bunkers. Diesel has been detected in several wells downgradient of the

166-KW fuel bunker vertical profile sampling while drilling of several extraction wells in 2008. Sampling in CY 2009 and CY 2010 did not detect TPH in downgradient wells. Groundwater detections were not observed at well 199-K-188 during drilling.

### 3.5 Conclusions

The current status of the 100-KR-4 OU illustrates that remedial progress has been achieved for the plume areas associated with each of the three P&T systems currently active within this OU. The conclusions for the OU, based on each of the RAOs, are presented below:

- **RAO #1:** Protect aquatic receptors in the river bottom substrate from contaminants in the groundwater entering the Columbia River.

#### Results:

- Capture zone analysis suggests that operation of the three P&T systems under the recommended 2010 operating conditions results in capture efficiency between 90 and 100 percent for most of the hexavalent chromium plumes in the 100-KR-4 OU.
- Based on the limited aquifer tube data for CY 2010, the extent of hexavalent chromium continuing to be discharged to the Columbia River within the 100-KR-4 OU appears to have decreased in response to P&T activities.
- The three P&T systems at the 100-KR-4 OU have removed significant amounts of hexavalent chromium from the unconfined aquifer. In total, the three treatment systems have removed an estimated 570 kg of hexavalent chromium from the shallow, unconfined aquifer.
- The KR4 P&T system has removed a substantial mass of hexavalent chromium from the plume zones located along the 116-K-2 Trench. Between October 1997 and December 30, 2010, the KR4 system extracted and treated approximately 5.65 billion L (1.44 billion gal) of groundwater, resulting in removal of 349.5 kg of hexavalent chromium from the aquifer. As a probable result of these activities, the hexavalent chromium concentrations in 30 of 32 monitoring and extraction wells sampled near the 116-K-2 Trench area declined between fall 2009 and fall 2010.
- The KR4 P&T system has largely attained the RAO for river protection along the central portion of the 116-K-2 Trench area. Fall 2010 hexavalent chromium concentrations were less than 10 µg/L in monitoring wells 199-K-21, 199-K-117A, and 199-K-19 and extraction wells 199-K-119A, 199-K-125A, and 199-K-127. Elevated hexavalent chromium concentrations remain in plume areas located at either end of the 116-K-2 Trench (i.e., KR4 plume and the southern portion of the K North plume).
- Hexavalent chromium concentrations remained elevated at former compliance monitoring well 199-K-18, (located in the KR4 plume) for the first half of CY 2010 before declining during the second half of the year. The reason for this increase is not known, but it may have resulted from changes in groundwater flow dynamics due to nearby downgradient KR4 system extraction wells (e.g., 199-K-145 and 199-K-162) that are accelerating the downgradient transport of more highly contaminated groundwater originally located further upgradient in this plume.
- The KW system started up in January 2007. As of December 31, 2010, the system extracted approximately 1.05 billion L (278 million gal) of groundwater and removed an estimated 137 kg of hexavalent chromium. Long-term trends for hexavalent chromium in the monitoring network for the KW plume suggest that this system is rapidly reducing the remaining mass of this plume.

- The KX P&T system was designed to treat the K North hexavalent chromium plume, located between the northern end of the 116-K-2 Trench and the N Reactor fence line. Two KX extraction wells were added to remediate the small KE plume. The KX system began partial operation in November 2008 and became fully operational in early February 2009. The system is currently extracting groundwater at a rate of approximately 1,720 L/min (455 gpm). Since system startup, more than 1.5 billion L (447 million gal) of water have been treated and approximately 83.9 kg of hexavalent chromium have been removed. Although the system has been operating a relatively short time, the data collected during CY 2010 and the capture zone analysis suggest that this system should intercept the majority of the K North plume before it can discharge to the Columbia River.
- The ratio of hexavalent chromium mass to the unit volume of groundwater treated at the 13-year-old KR4 system is diminishing as the hexavalent chromium plume associated with the 116-K-2 Trench is cleaned up. A “tailing effect” such as this is typical for P&T systems as they mature. This conclusion is based on observed declines in chromium trends in the treatment system influent and at extraction wells to below aquatic standards (in some instances). Both the KW and KX systems generally retain higher ratios of hexavalent chromium per unit volume of groundwater treated, but decreasing concentrations are observed seasonally, and some extraction wells have been taken offline as concentrations temporarily or permanently drop below 10 µg/L. Current extraction well layouts in the vicinity of the two KR4 plumes are successfully reducing concentrations at known hot spots at the ends of the 116-K-2 Trench. The operation of extraction wells in the center of the former plume where hexavalent chromium concentrations are now below 10 µg/L reduces the influent concentrations and also reduces the efficiency of chromium removal by the IX resins.

For other key plumes in the 100-KR-4 OU during CY 2010, the results are as follows:

- Tritium activities below the 200,000 pCi/L DWS are widespread across the 100-KR-4 OU. Activities above the DWS are confined to plumes that appear to be derived from the 118-K-1 Burial Ground and the 116-KE-1 gas condensate crib.
  - Strontium-90 near the 116-K-2 Trench has generally been attributed to discharges of cooling water associated with failed fuel rods. The maximum activity of strontium-90 near the 116-K-2 Trench during CY 2010 was 190 pCi/L in new RI well 199-K-200. This upgradient hot spot suggests that strontium-90 in this area is derived from the 116-K-2 Trench.
  - Carbon-14 in groundwater is closely associated with the 116-KE-1 and 116-KW-1 gas condensate cribs and is present above the 200,000 pCi/L DWS at wells downgradient of the two cribs. Data currently do not suggest that carbon-14 is reaching the Columbia River; however, sampling of aquifer tubes within the potential discharge areas is needed to verify this conclusion.
- **RAO #2:** Protect human health by preventing exposure to contaminants in groundwater.

The interim remedial action ROD (EPA/ROD/R10-96/134) establishes a variety of institutional controls that must be implemented and maintained throughout the interim action period. These provisions include the following:

- Access control and visitor escorting requirements
- Signage providing visual identification and warning of hazardous or sensitive areas
- Excavation permit process to control all intrusive work (e.g., well drilling and soil excavation)
- Regulatory agency notification of any trespassing incidents

The effectiveness of institutional controls is presented in the *2004 Site Wide Institutional Controls Annual Assessment Report for Hanford CERCLA Response Actions* (DOE/RL-2004-56) DOE/RL-2004-56. The findings of this annual report indicate that institutional controls were maintained to prevent public access, as required.

- **RAO #3:** Provide information that will lead to a final remedy.

**Results:** Fifteen new RI/FS wells and four planned RPO wells will provide geologic and hydrologic data to improve the conceptual site model for the 100-KR-4 OU. The data will also improve numerical modeling predictions of contaminant fate and transport simulations and also capture zone analysis.

### 3.6 Recommendations

Recommendations for the 100-KR-4 OU are as follows:

- Complete the Phase 3 drilling and realign these wells with the existing wells to increase capture efficiency.
- A robust aquifer tube monitoring program should be executed for the fall of 2011 to better define hexavalent chromium concentrations that are reaching the Columbia River.
- Monitoring wells 199-K-29 and 199-K-30 (downgradient of the 116-KE-1 gas condensate crib) and well 199-K-109A (downgradient of the KE Basin) were decommissioned in December 2010 following sampling and borehole logging. The wells were used to monitor carbon-14 and tritium concentration trends in these areas. The installation of replacement wells should be considered for wells 199-K-109A, 199-K-29, and 199-K-30 to provide sufficient monitoring coverage of these mobile radionuclides.
- For existing wells, and new RI or Phase 3 RPO wells, the passive sampling technique used in the 100-D Area should be considered for the 100-K Area. The vertical distribution of hexavalent chromium or other analytes observed in RI wells may be tested with this sampling method in a less disturbed aquifer setting. Passive sampling would need to be adjusted to routine sampling schedules. Passive sampling should be scheduled to examine contaminant distributions at several river stages.
- One to two additional monitoring wells will be needed inland to the southeast and southwest of well 199-K-182 to bound the hexavalent chromium plume near the 100-NR-2 OU. Concentrations at this well remained well above 50 µg/L in CY 2010.
- New wells are needed to replace those removed due to building/facility demolition and waste site remediation. Wells lost or expected to be lost to surface remediation include former injection well 199-K-35 and RI well 199-K-195 at the 183.1-KW headhouse, as well as monitoring well 199-K-36 and RI well 199-K-188, following planned CY 2011 remediation at the 183.1-KE headhouse and 183.2 sedimentation basin.
- Few compliance wells remain within the 100-KR-4 OU groundwater monitoring network. Most wells located near the Columbia River are used as extraction and compliance wells. A few wells are located downgradient to determine the adequacy of remediation. Aquifer tubes are used to indentify contaminant levels at the river but do not penetrate deeply enough into the aquifer to provide acceptable data. Cultural resource issues at many locations may prevent further drilling downgradient toward the river. An evaluation to locate areas of possible river impact should be performed, which

would indicate suitable existing compliance wells and recommendations for additional wells as required.

- Evaluate the effectiveness of the 100-K Area P&T systems with respect to the 2012 Tri-Party Agreement Milestone M-016-110-TO1 target criteria. Groundwater concentration trends and hydraulic head data should be used with capture zone analysis and additional modeling to maximize the treatment capacity of existing P&T systems.

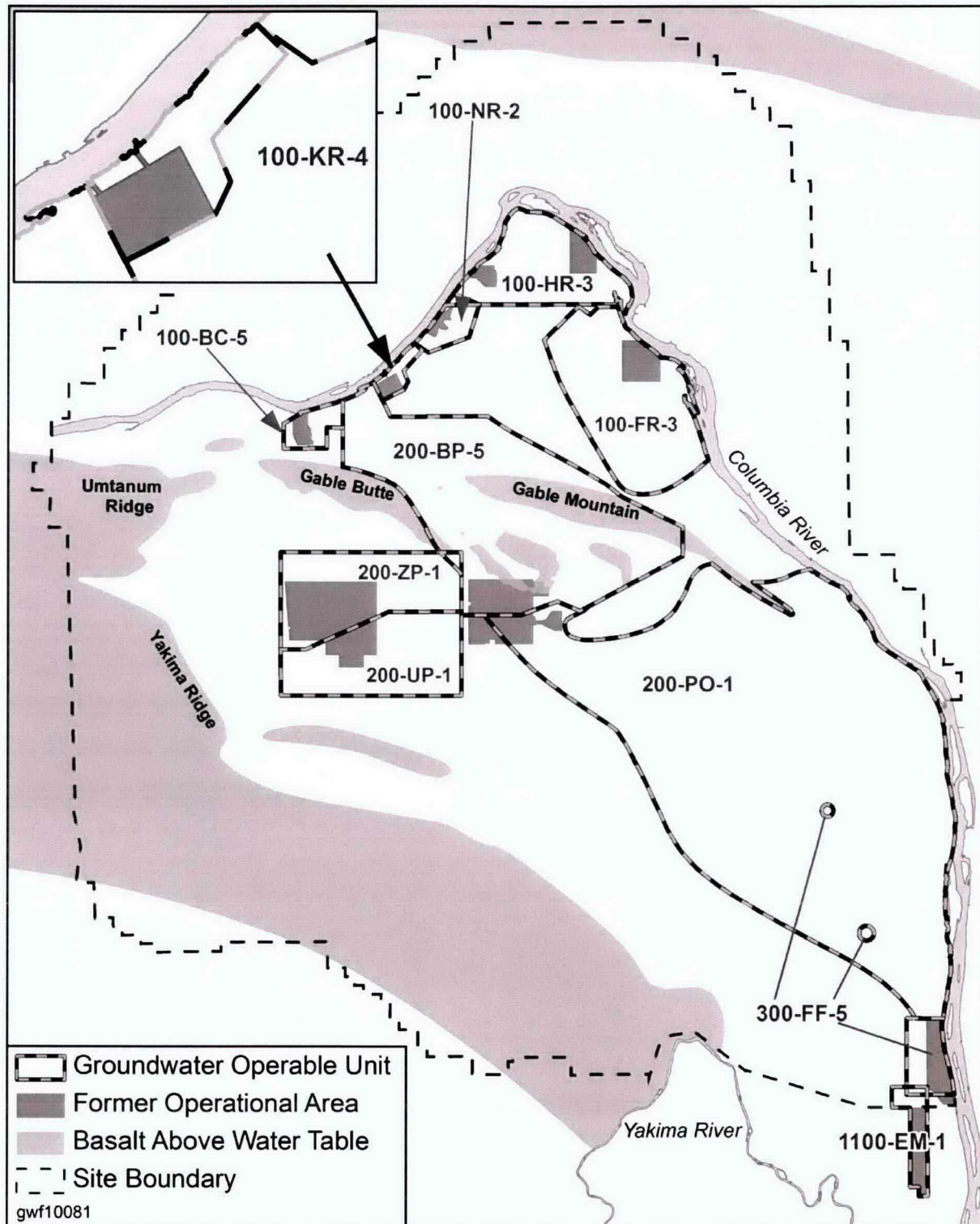
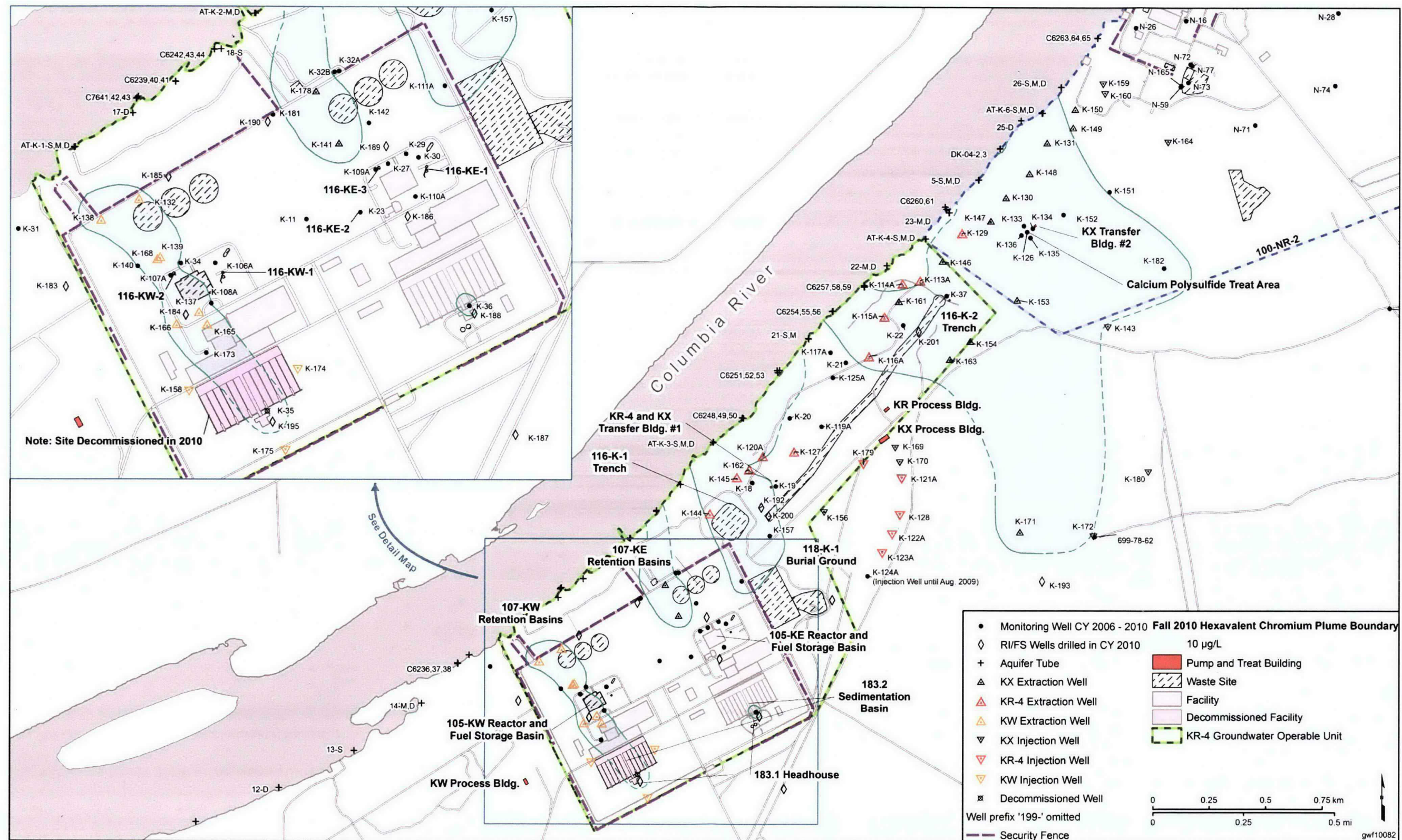


Figure 3-1. Location of the Hanford Site and the 100-KR-4 OU

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**Figure 3-2. 100-KR-4 OU Wells and Aquifer Sampling Tubes**

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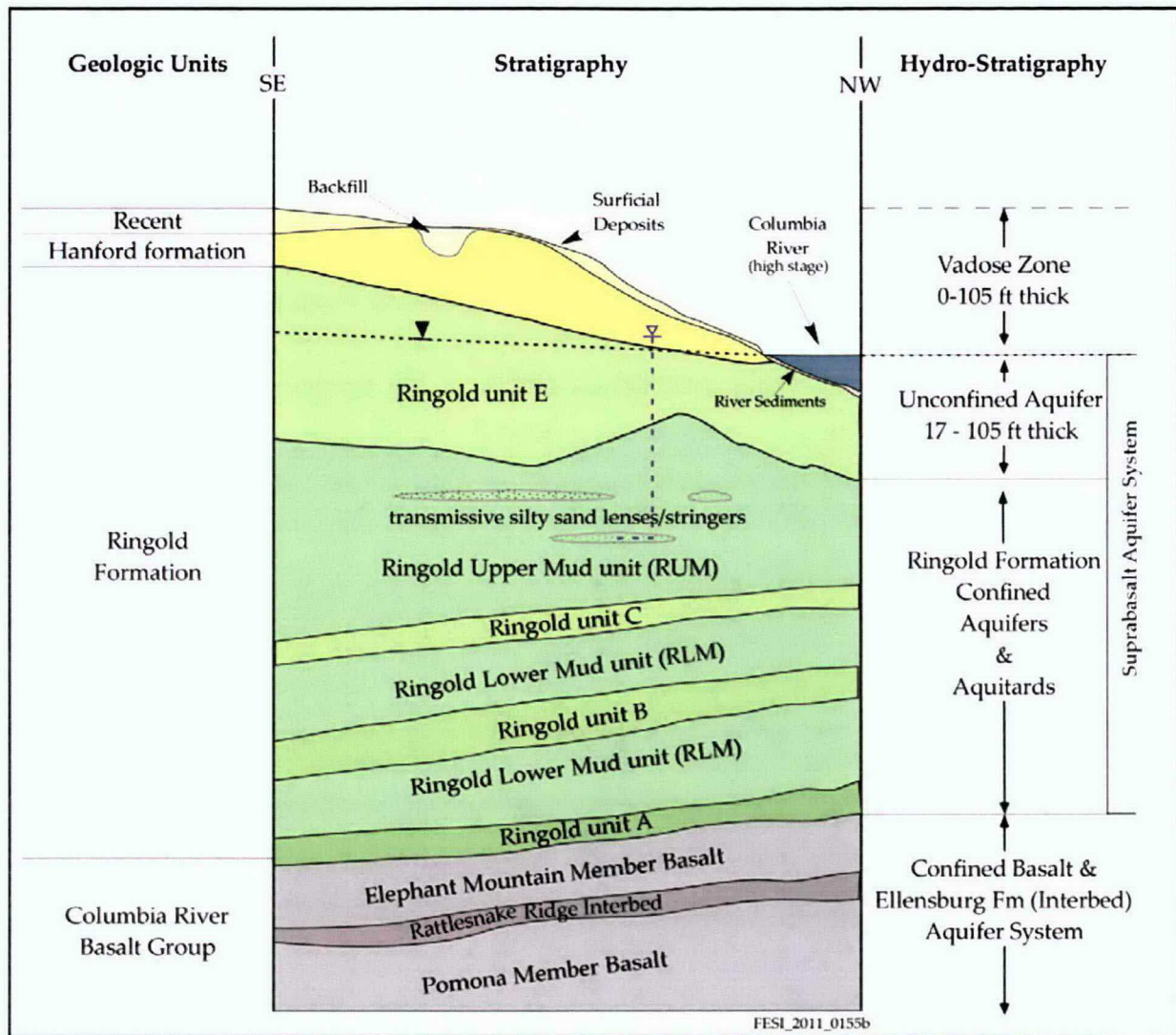


Figure 3-3. Generalized Stratigraphic Column at 100-KR-4 OU

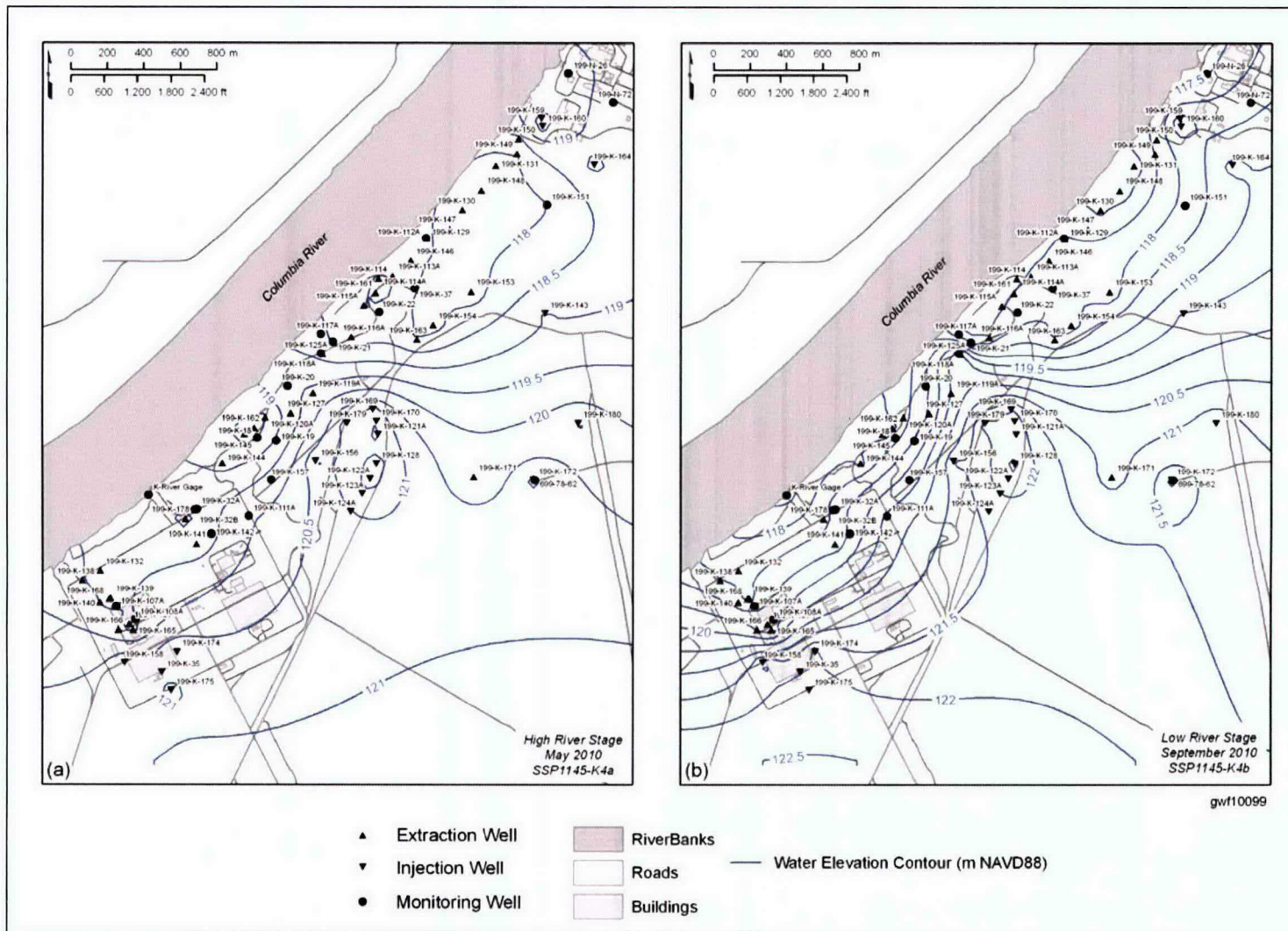


Figure 3-4. CY 2010 Spring and Fall Water Table Maps

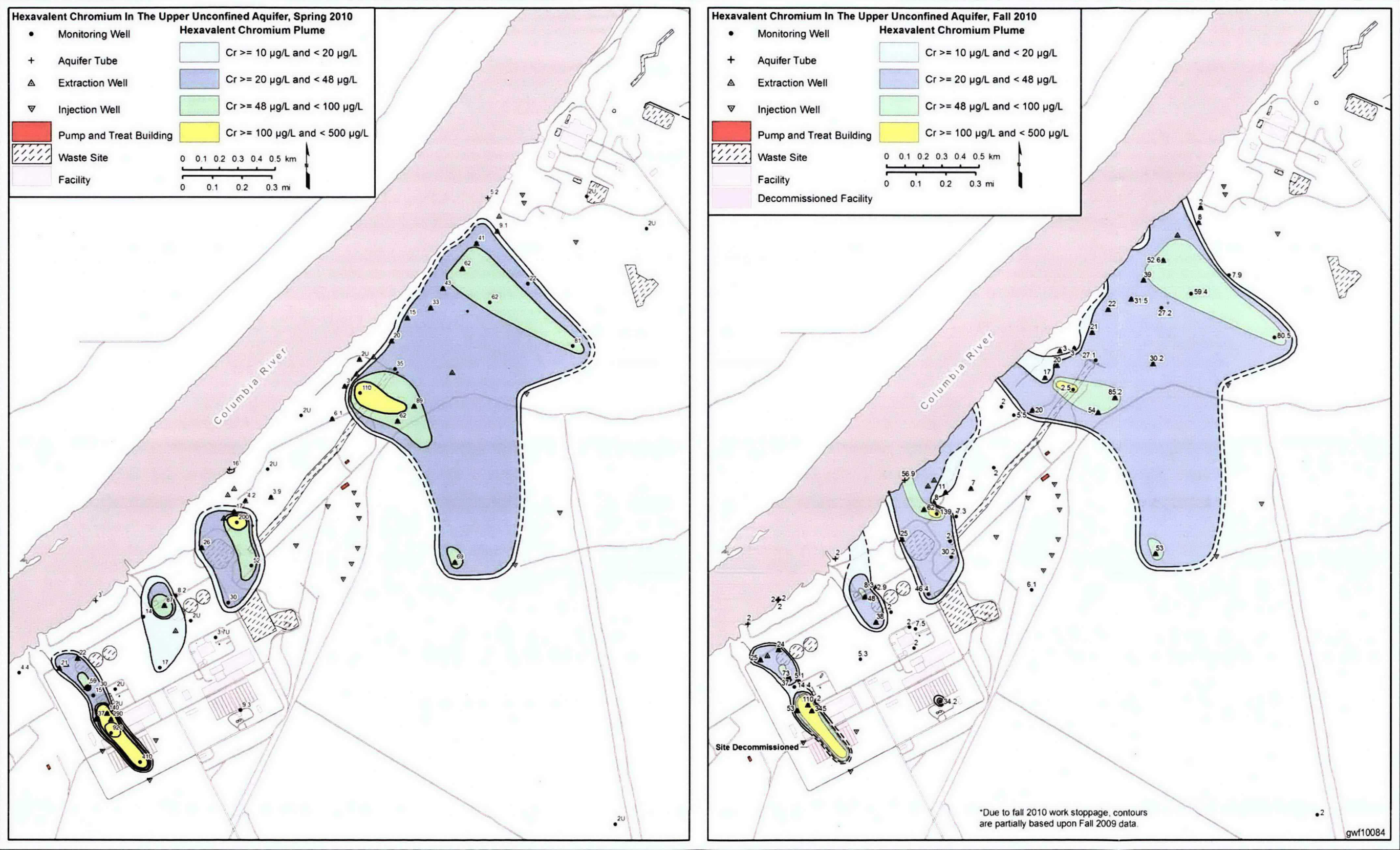


Figure 3-5. CY 2010 Spring and Fall Hexavalent Chromium Plume Maps

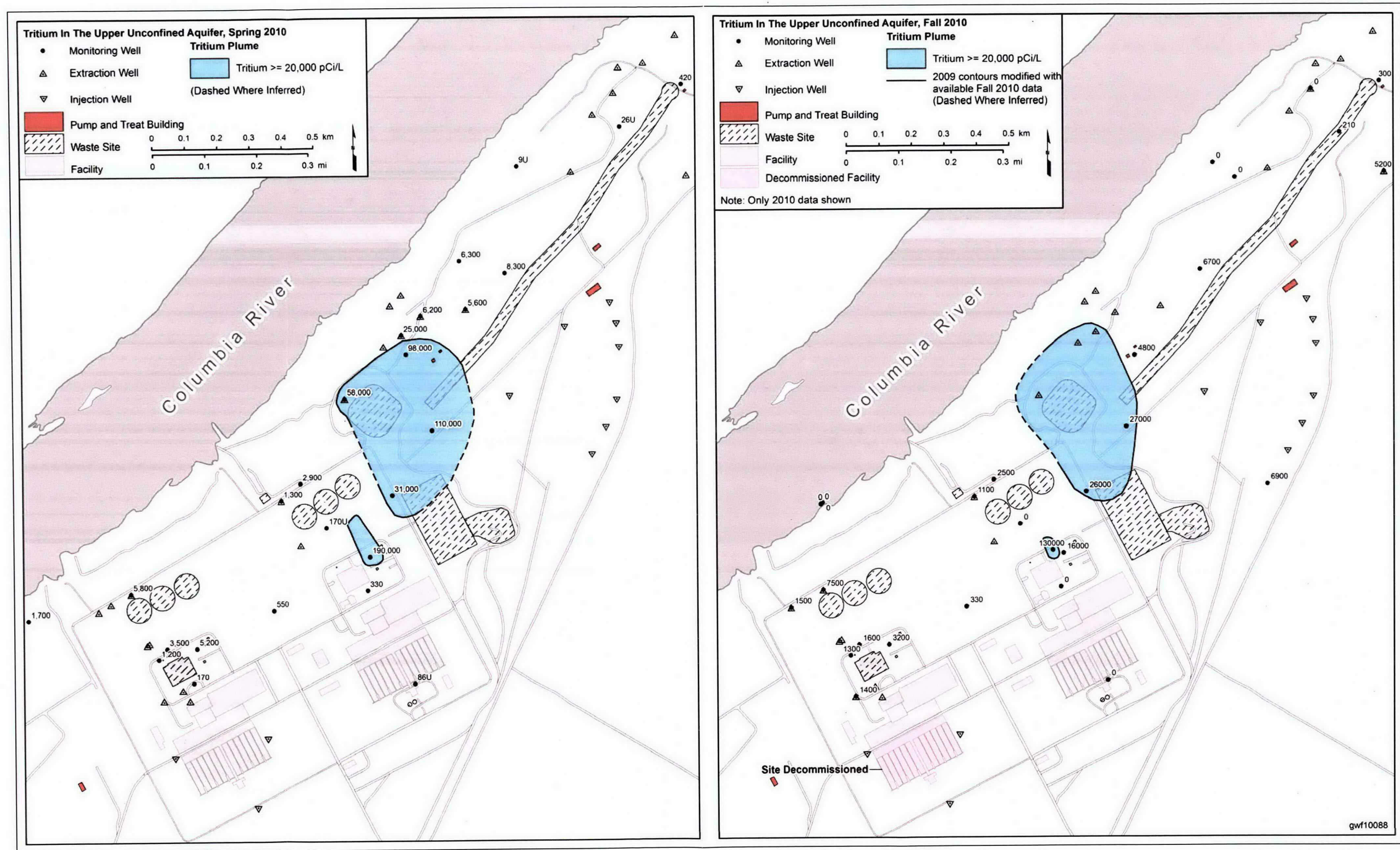


Figure 3-6. CY 2010 Spring and Fall Tritium Plume Maps



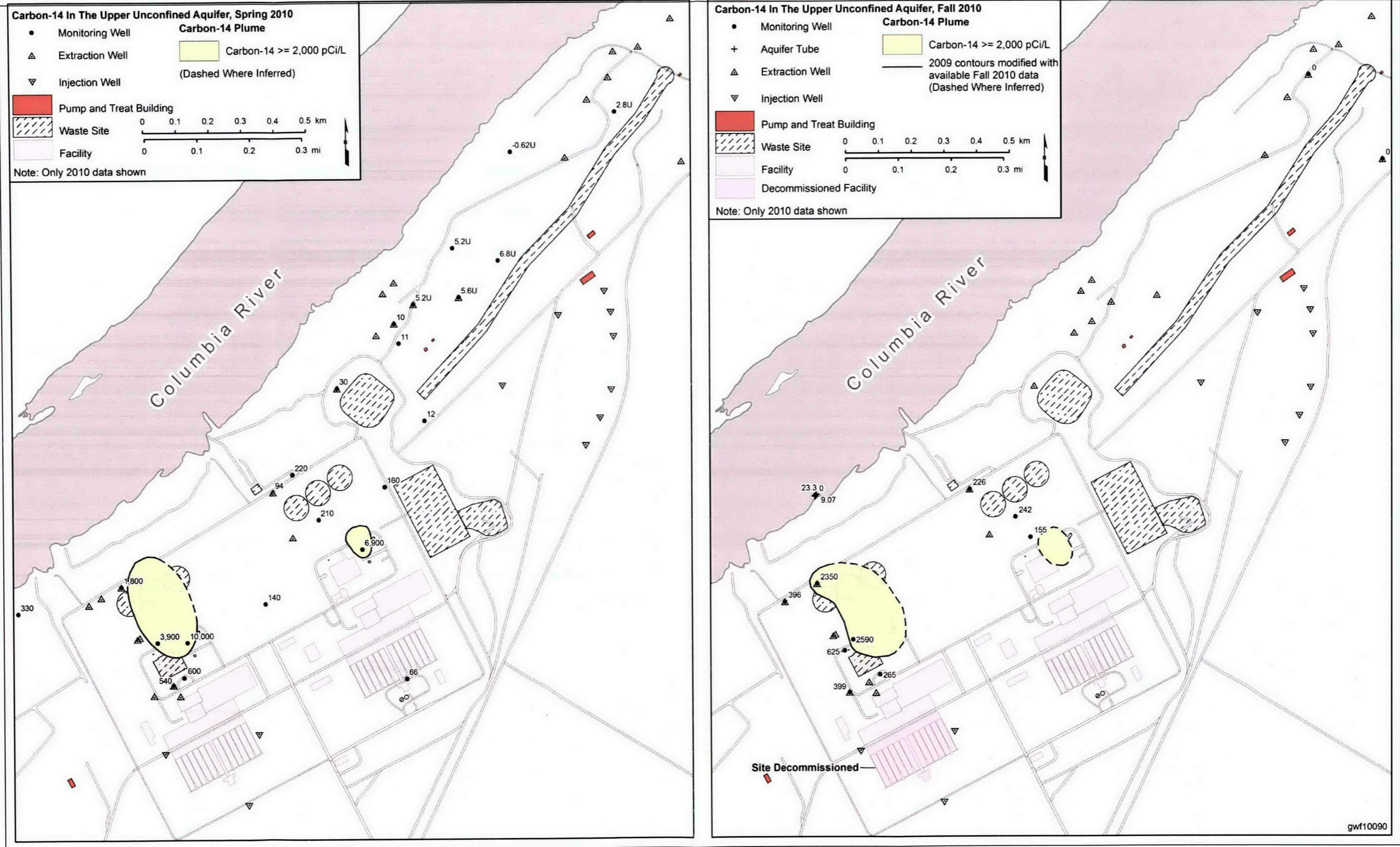


Figure 3-8. CY 2010 Spring and Fall Carbon-14 Plume Maps

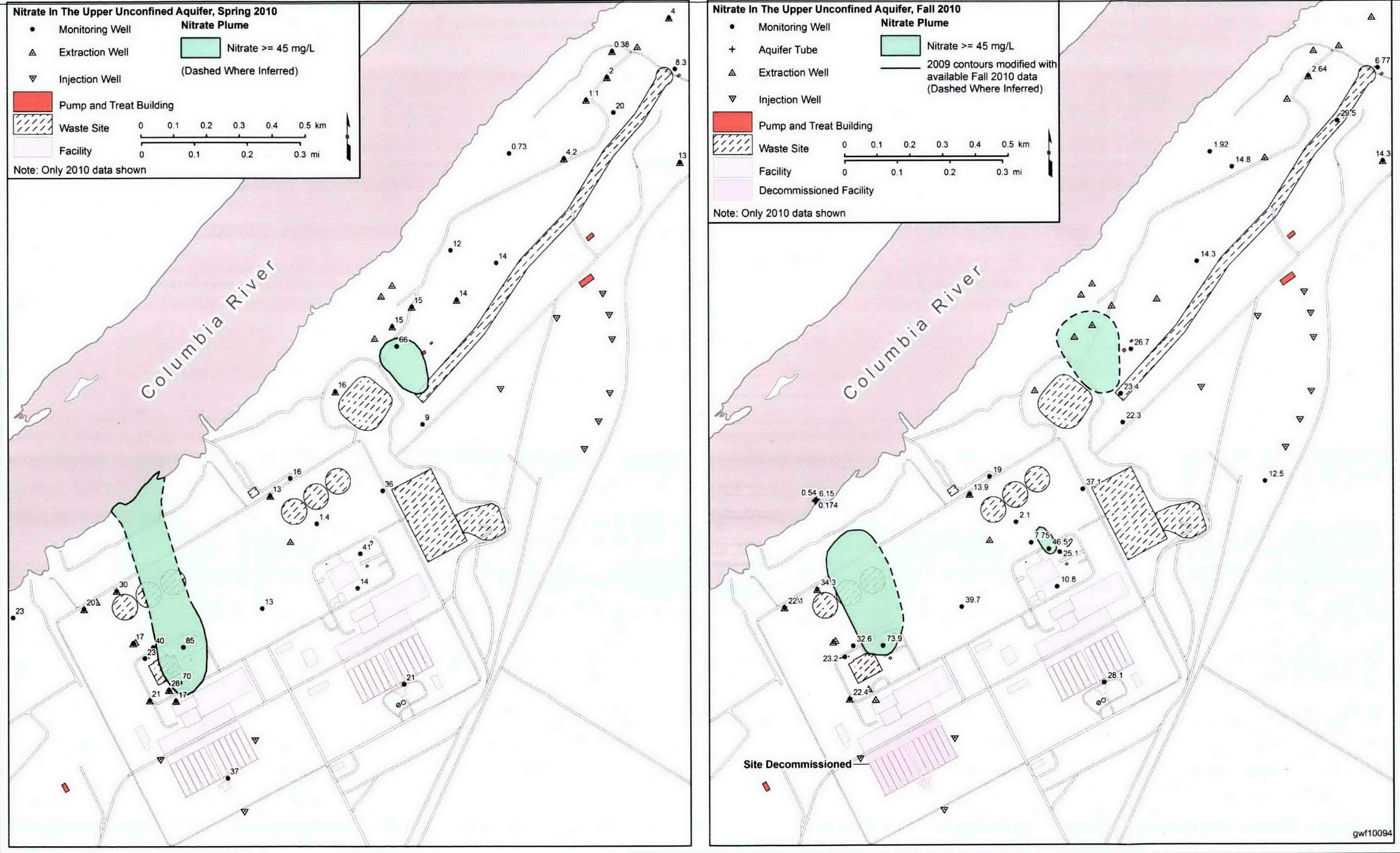


Figure 3-9. CY 2010 Spring and Fall Nitrate Plume Maps

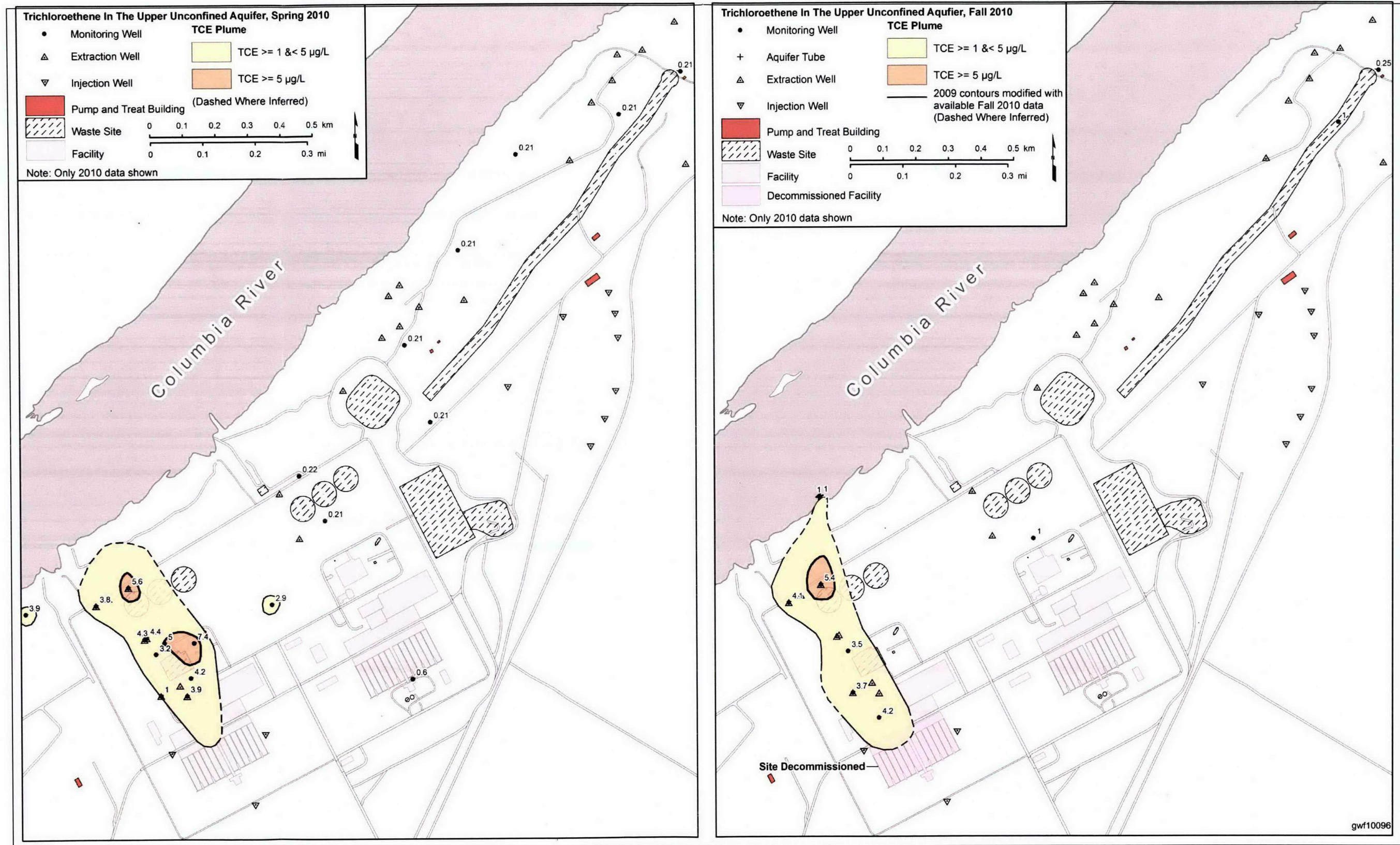


Figure 3-10. CY 2010 Spring and Fall TCE Plume Maps

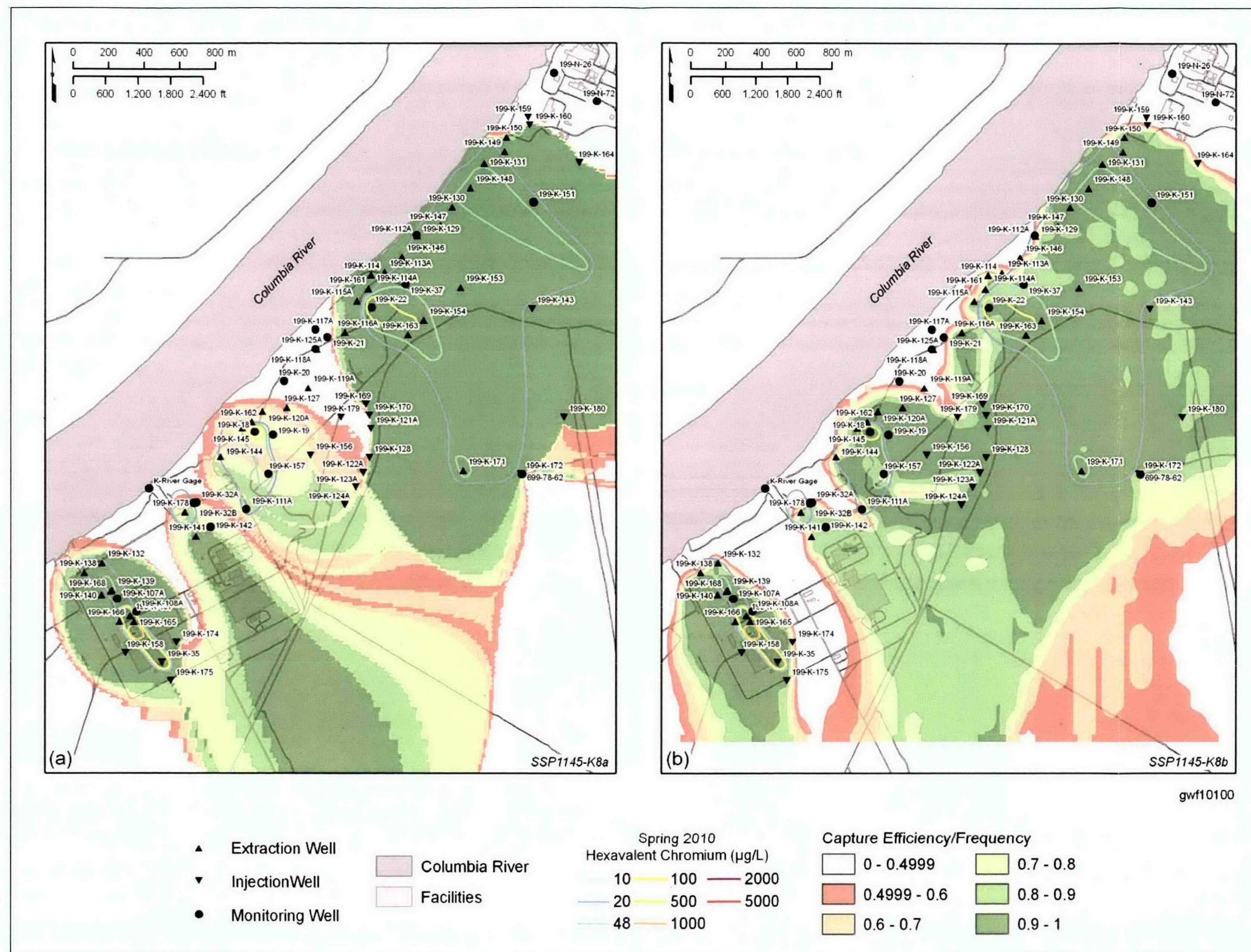


Figure 3-11. Composite Capture Zone Efficiency/Frequency Maps for the 100-KR-4 OU

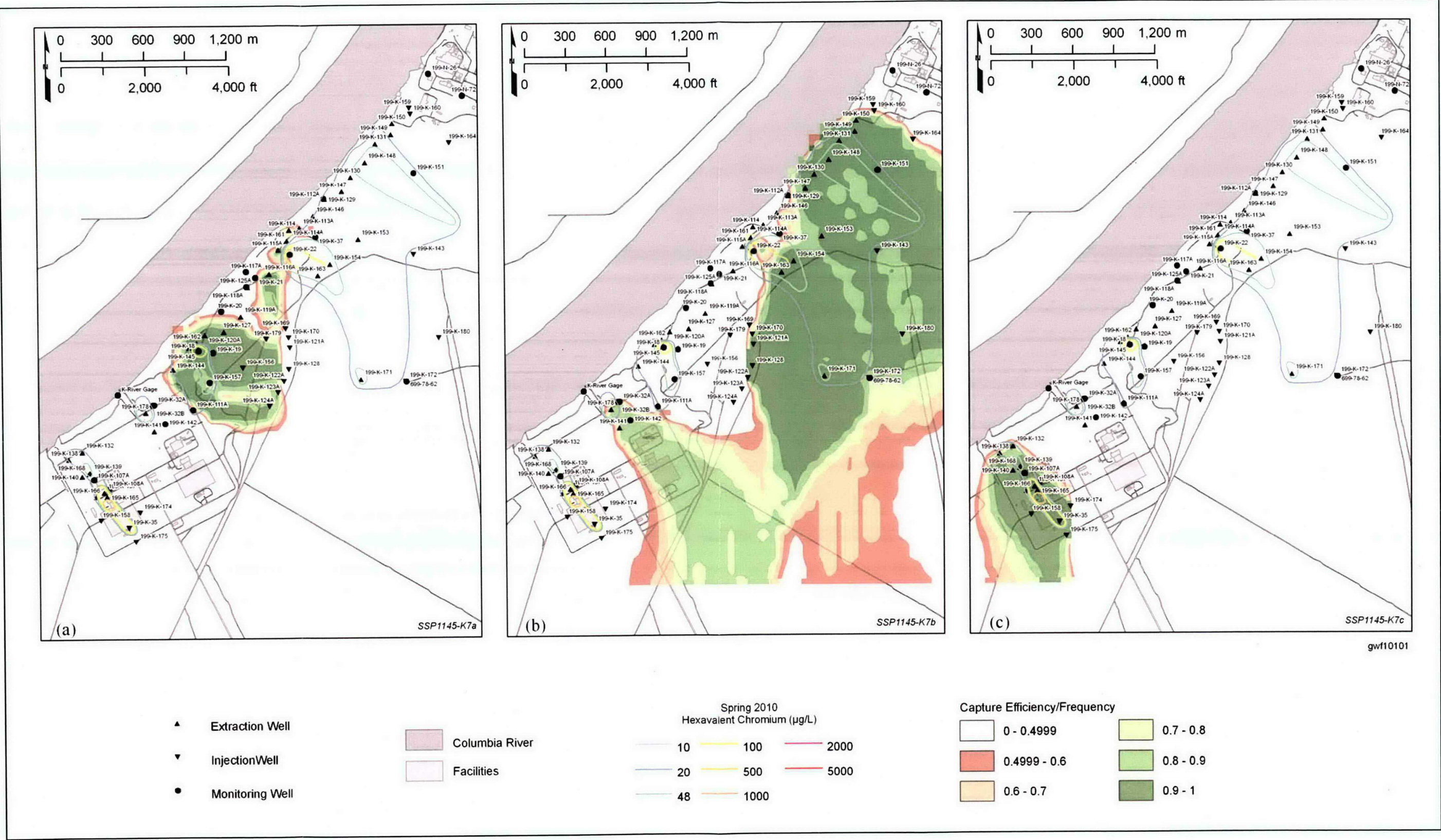
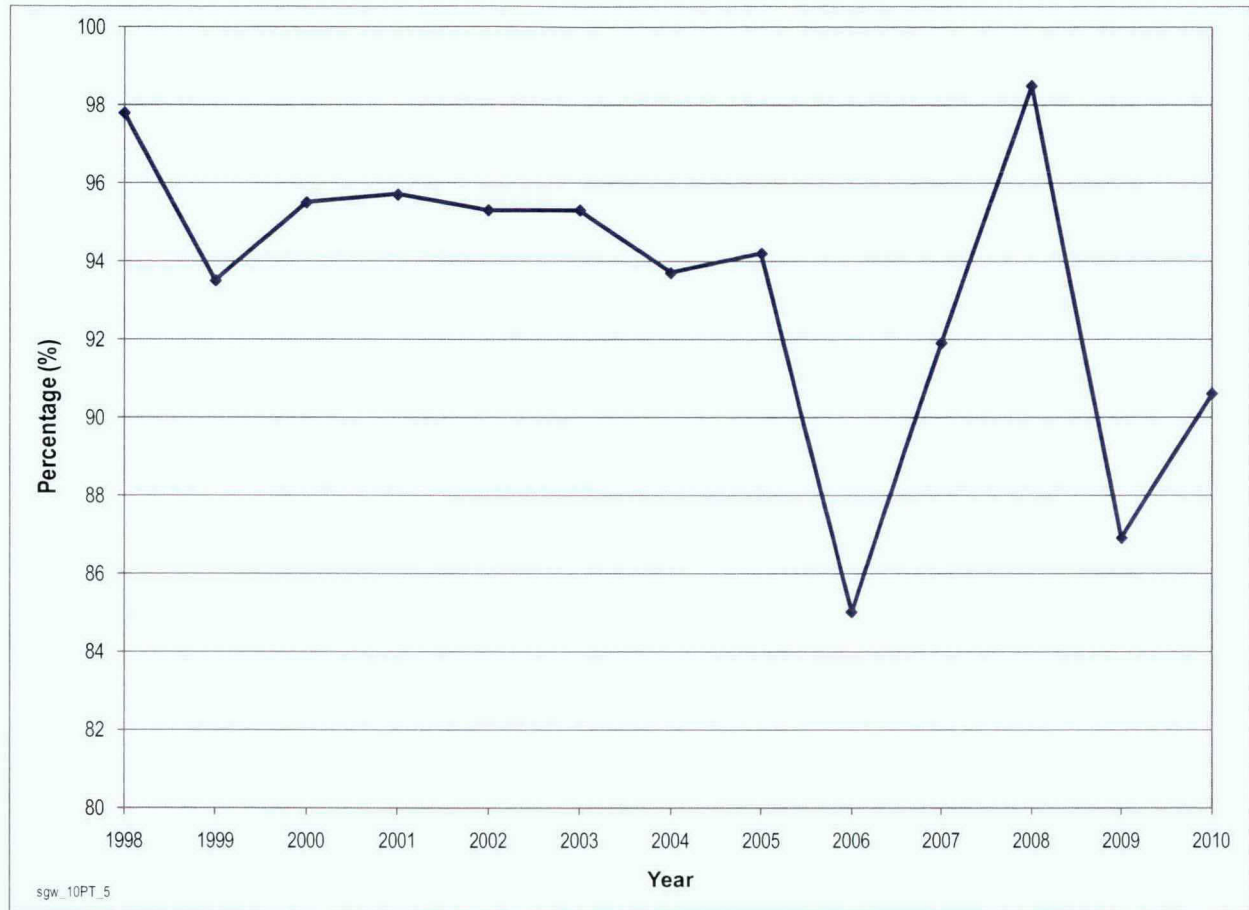
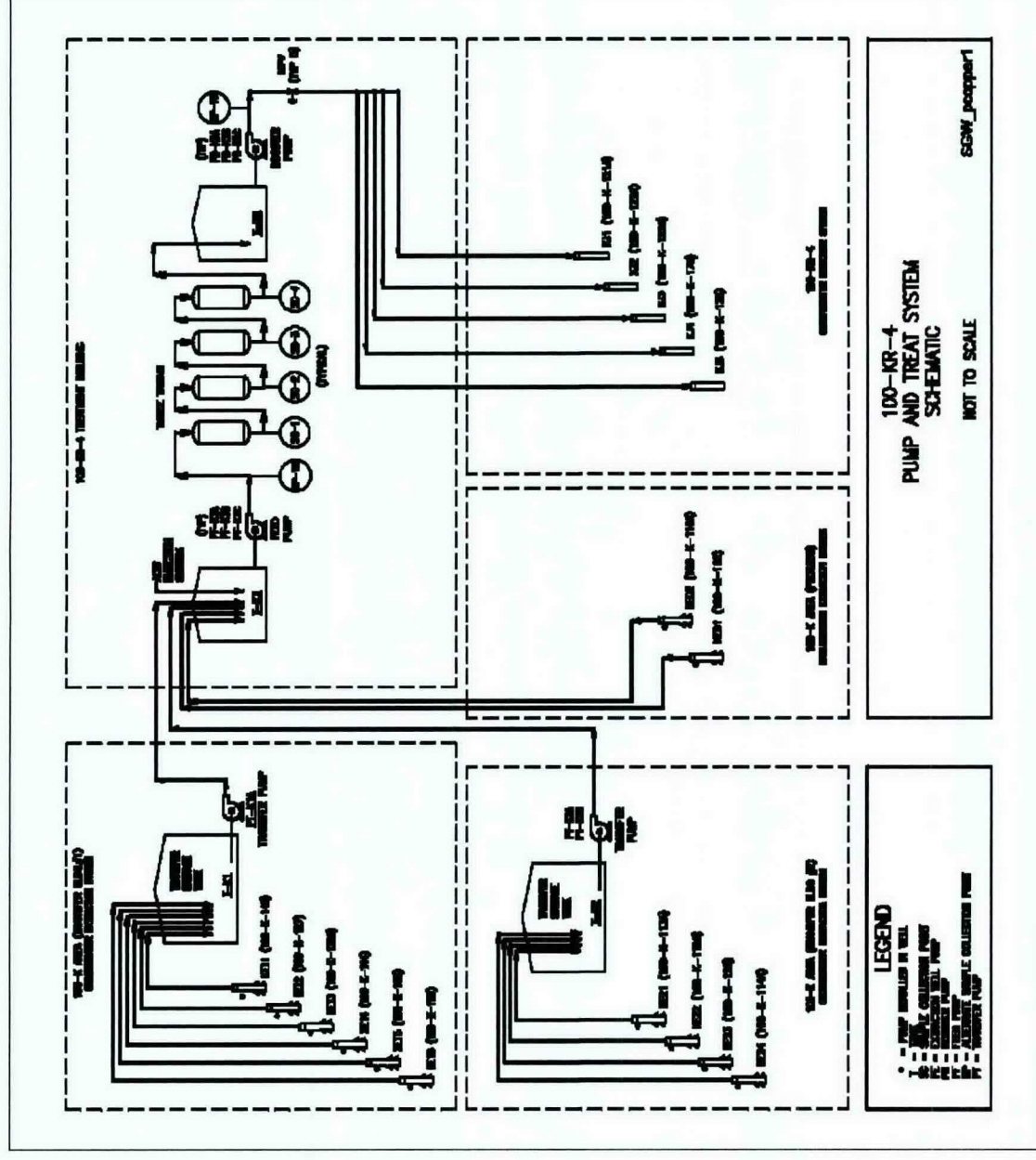


Figure 3-12. Individual Capture Zone Efficiency Maps for the 100-KR-4 OU P&T Systems



Notes: Average removal efficiency (% by mass) =  $[(\text{influent} - \text{effluent}) \div \text{influent}]$ .

**Figure 3-13 KR4 P&T System Average Removal Efficiencies**



**Figure 3-14. KR4 P&T System Schematic**

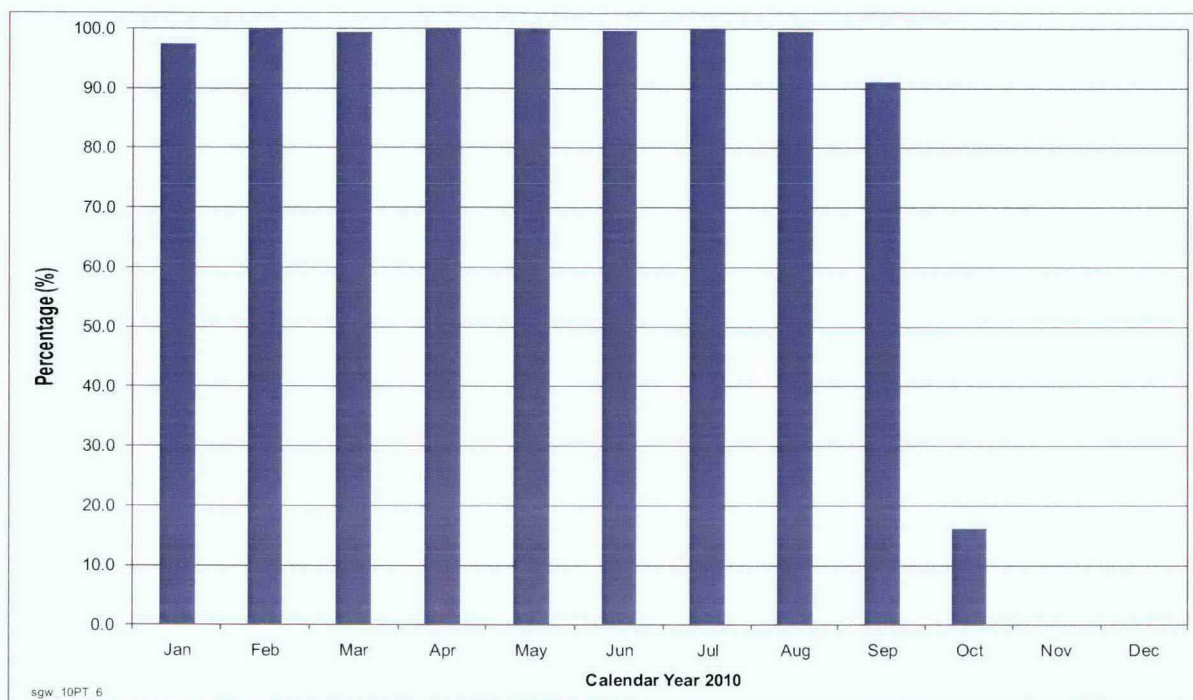


Figure 3-15. Monthly Online Availability for KR4 P&amp;T System, CY 2010

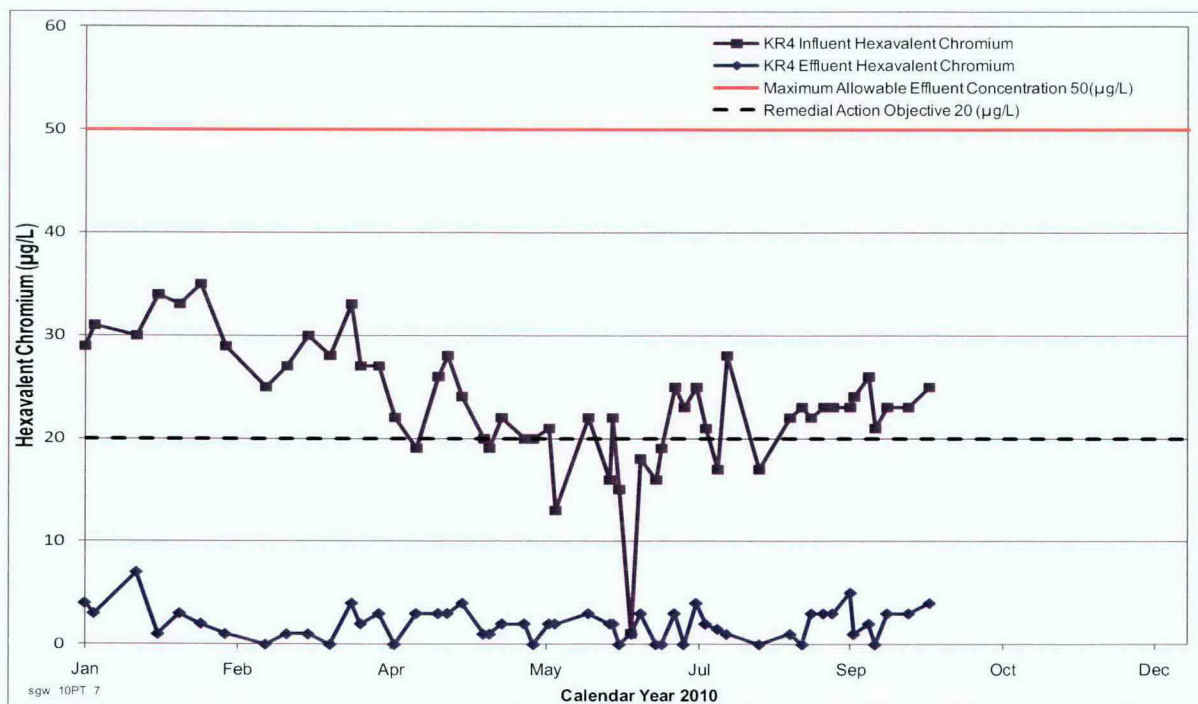


Figure 3-16. KR4 P&amp;T System Trends of Influent and Effluent Hexavalent Chromium Concentrations, CY 2010

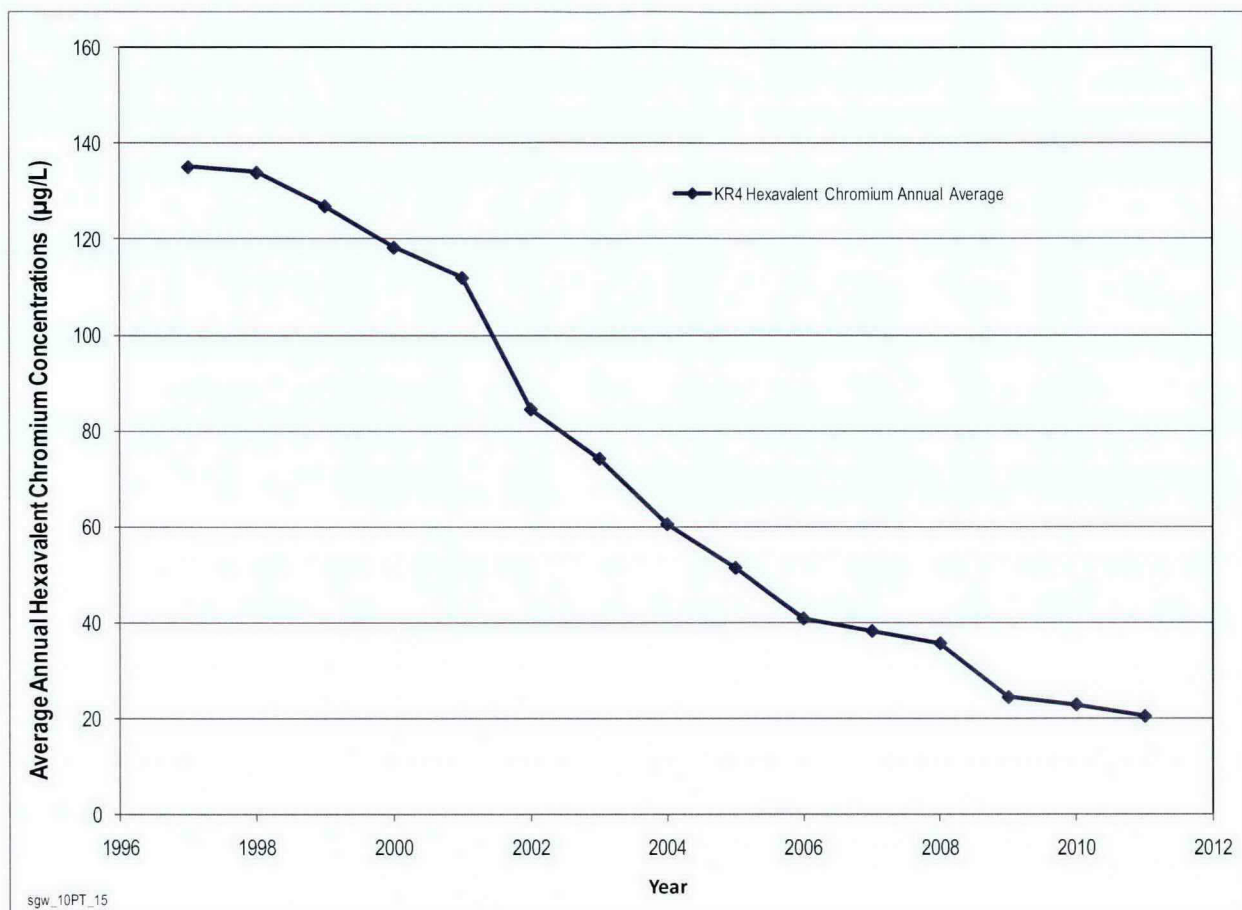
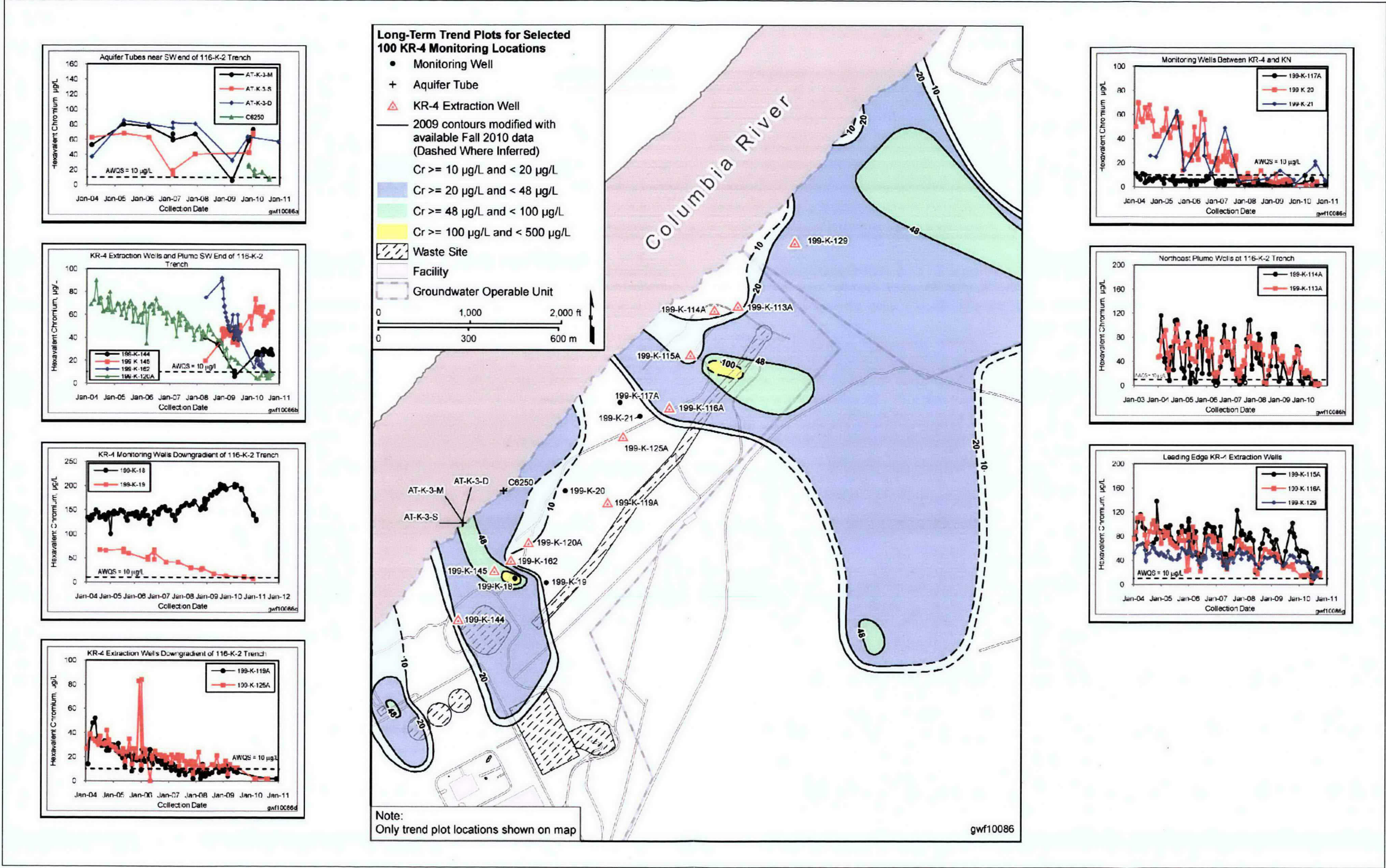


Figure 3-17. KR4 Annual Average Hexavalent Chromium Concentrations by CY Since 1997



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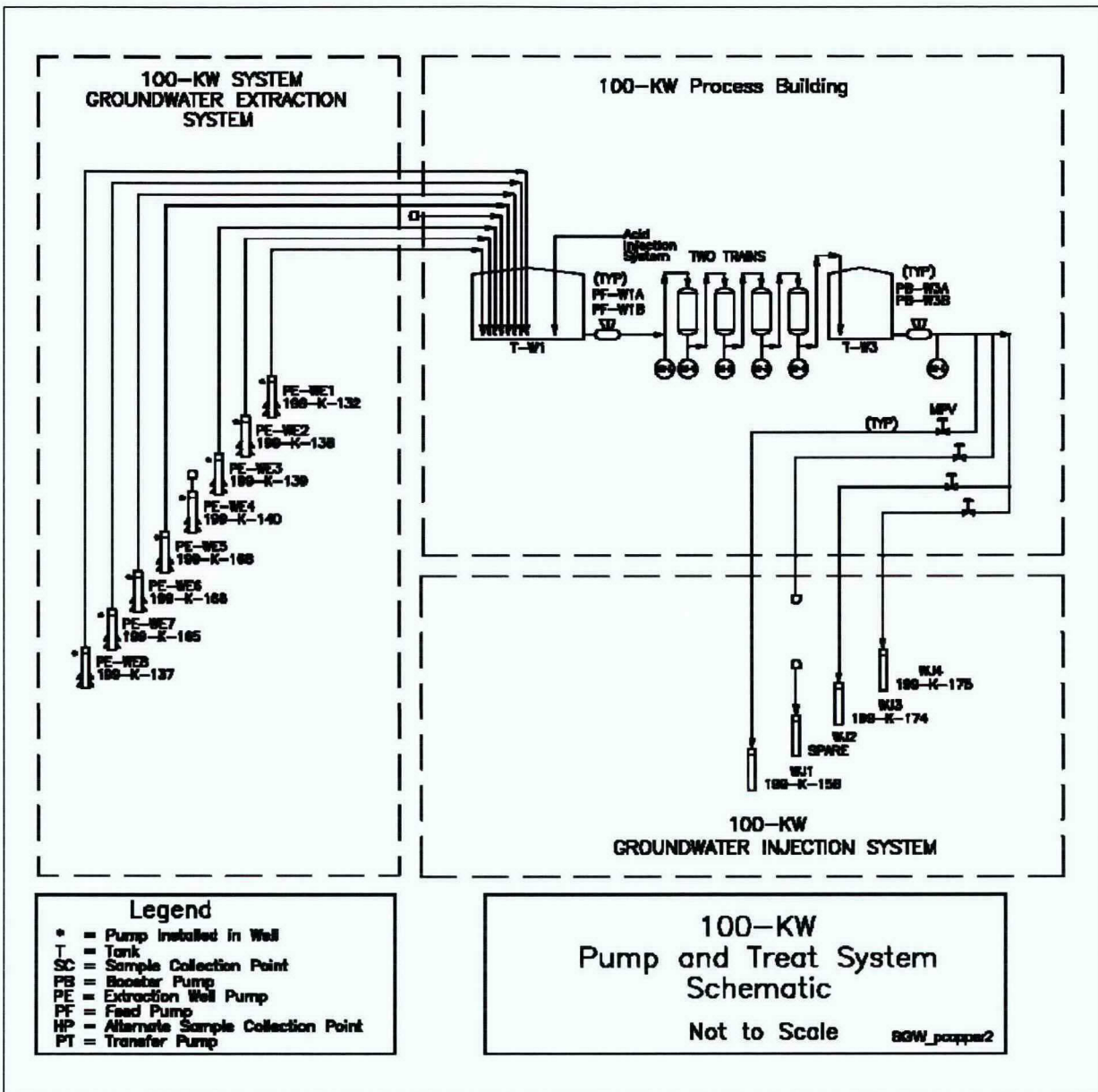


Figure 3-19. KW Reactor Area P&amp;T System Schematic

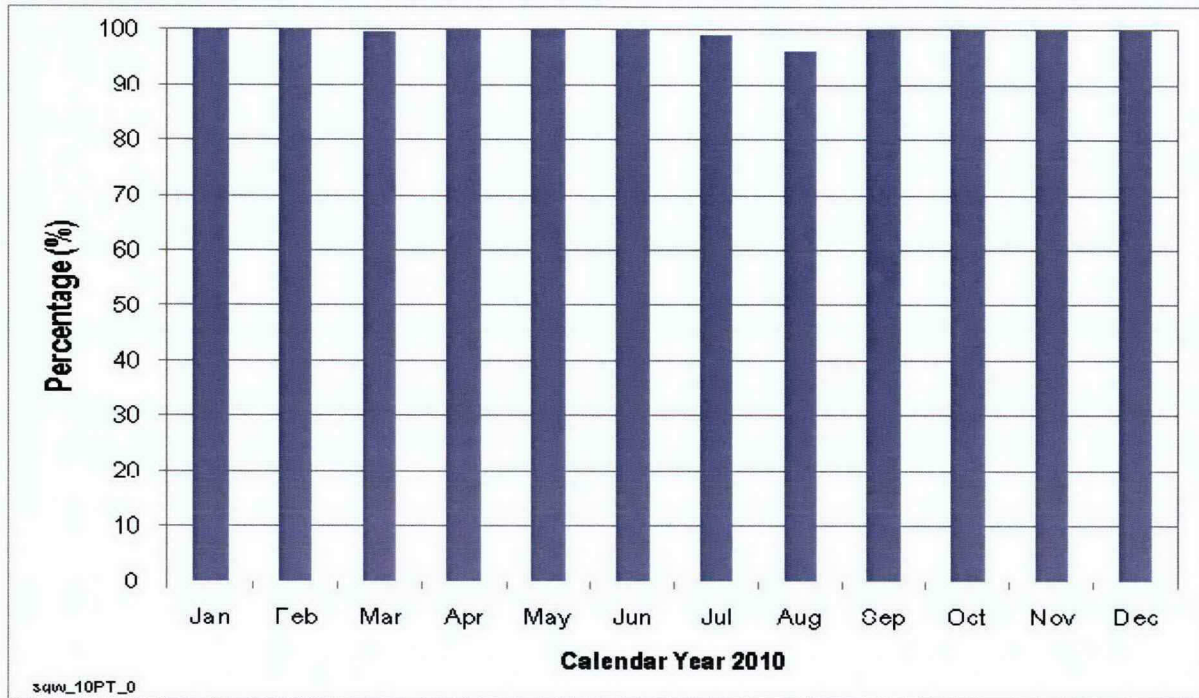


Figure 3-20. Monthly Online Availability for KW P&amp;T System, CY 2010

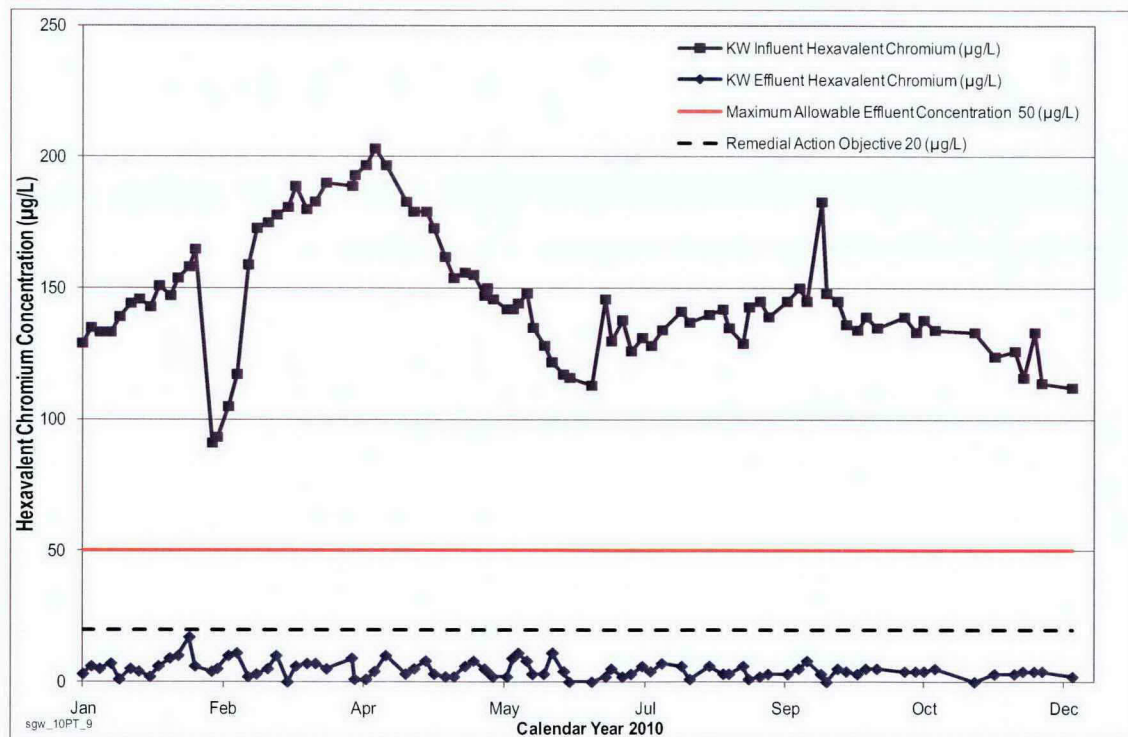
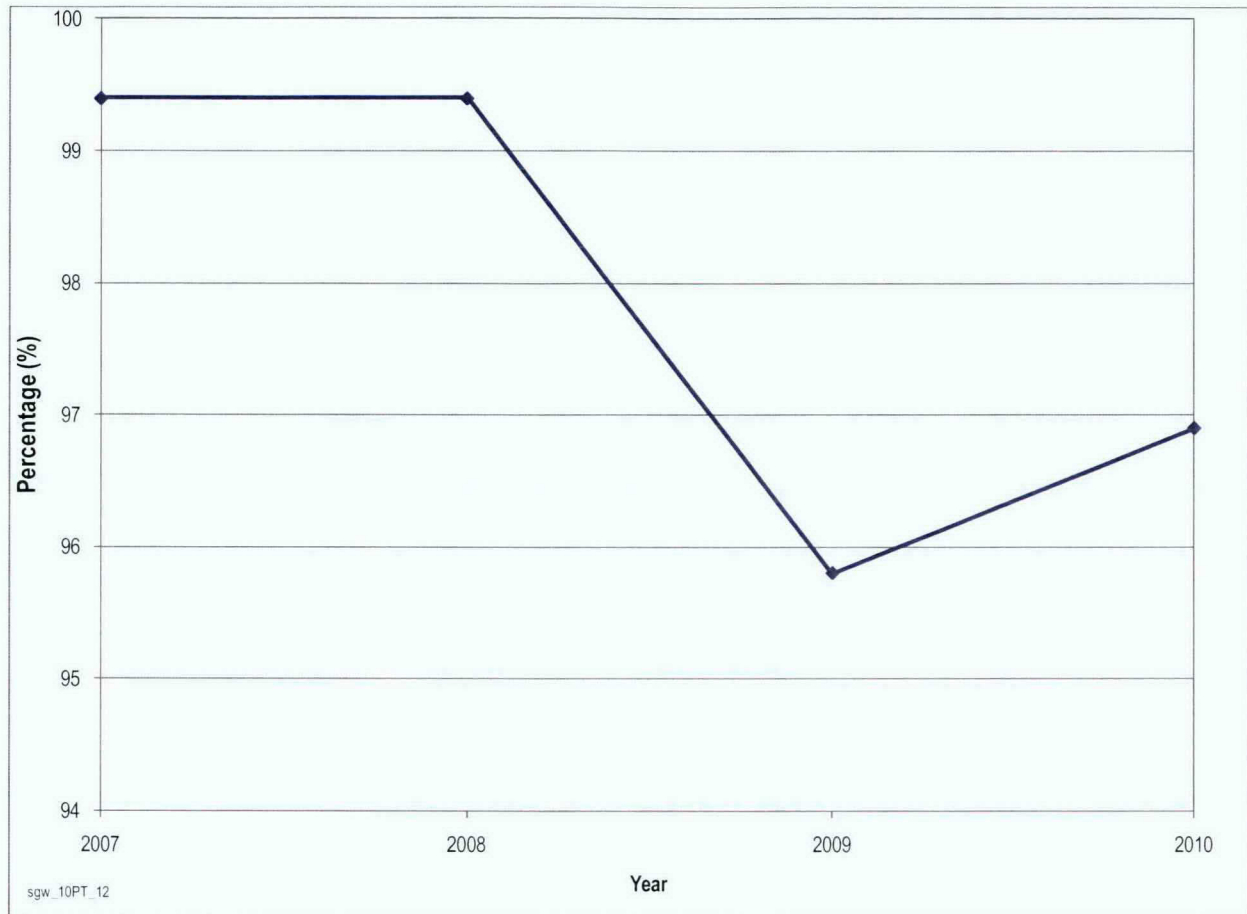


Figure 3-21. KW P&amp;T Trends of Influent and Effluent Hexavalent Chromium Concentrations, CY 2010



Note: Average removal efficiency (% by mass) =  $[(\text{influent} - \text{effluent}) \div \text{influent}]$ .

Figure 3-22. KW P&T System Average Removal Efficiencies

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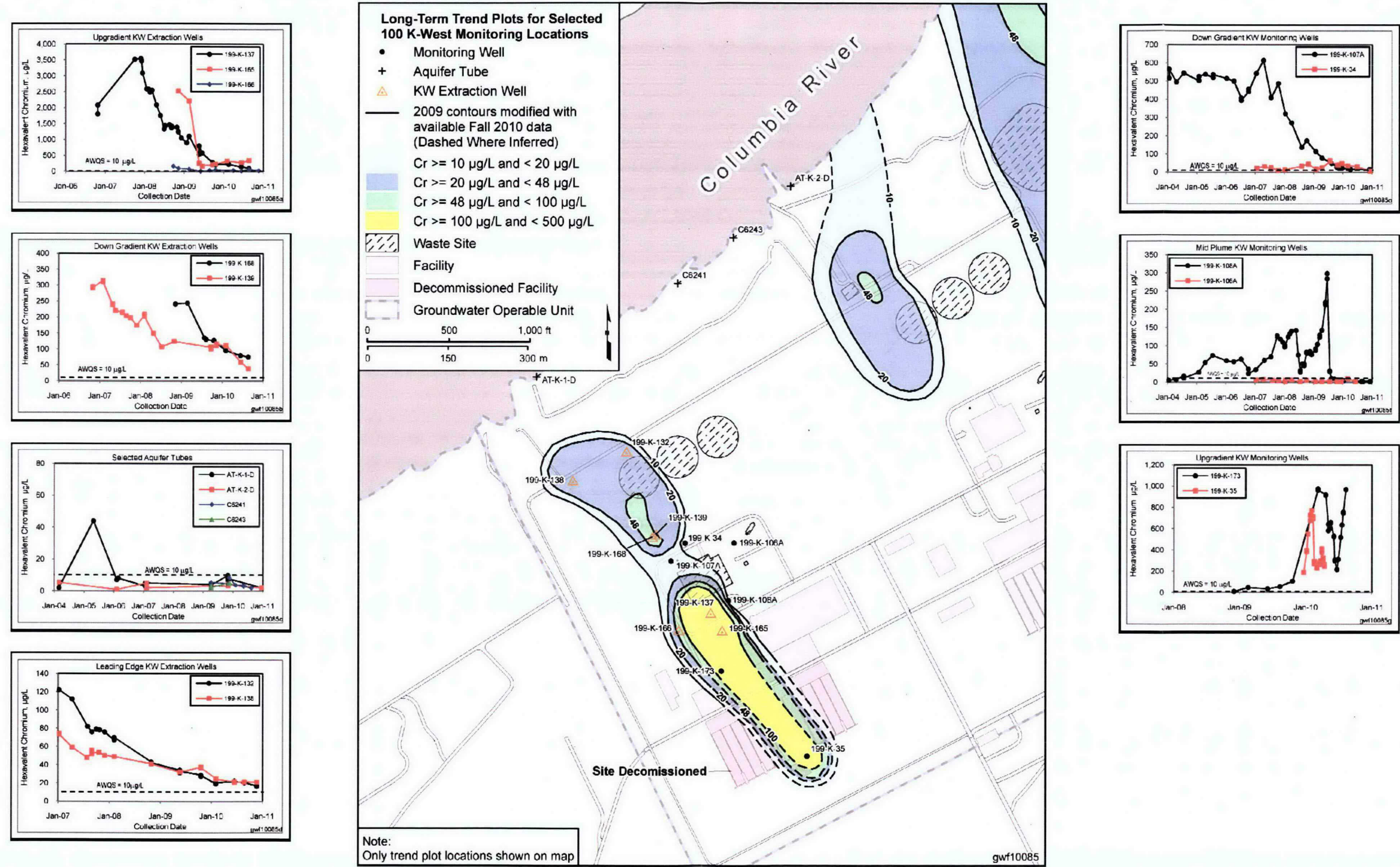


Figure 3-23. Hexavalent Chromium Concentration Trend Plots for Selected KW Reactor Area Monitoring Locations

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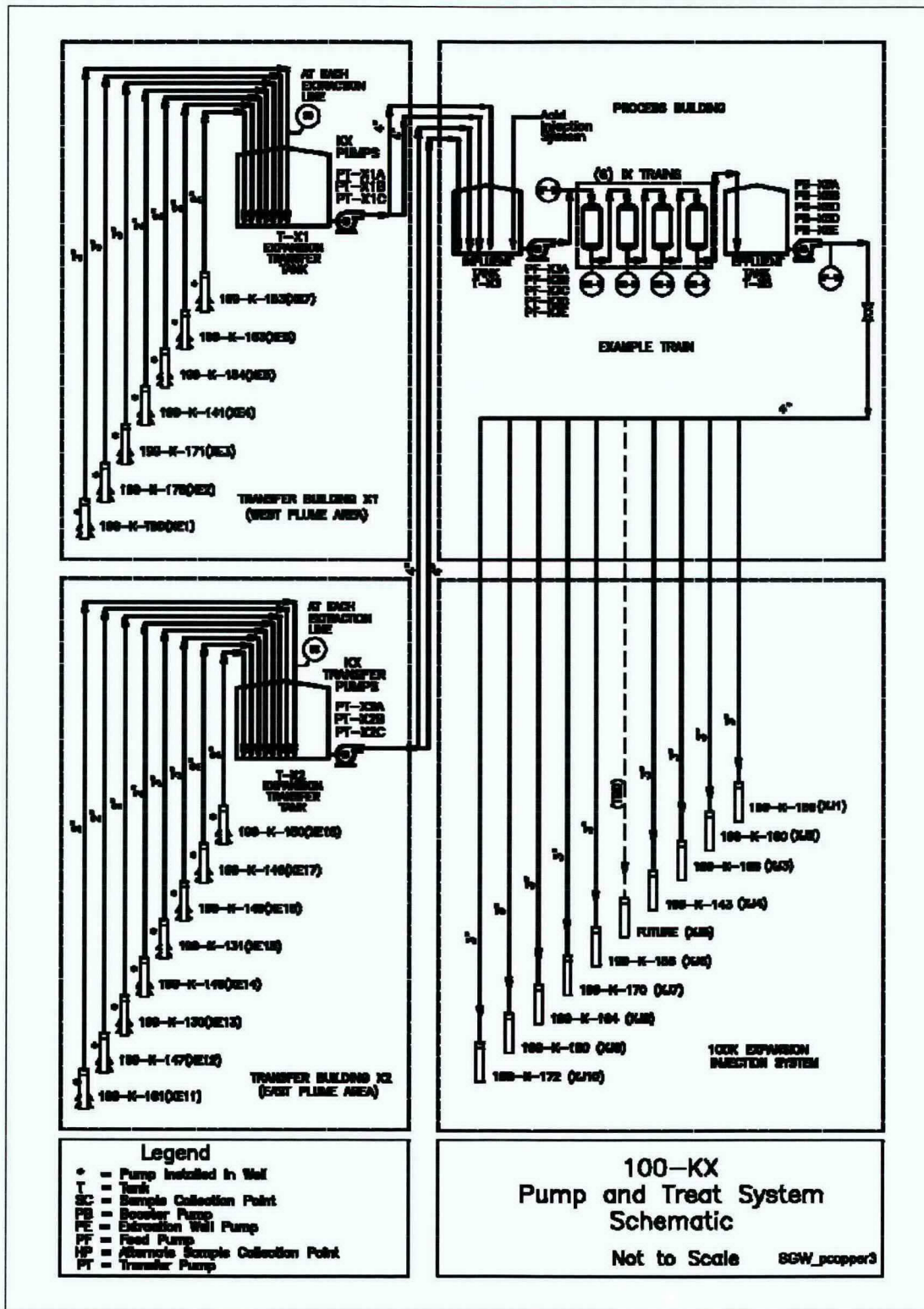


Figure 3-24. KX P&amp;T System Schematic

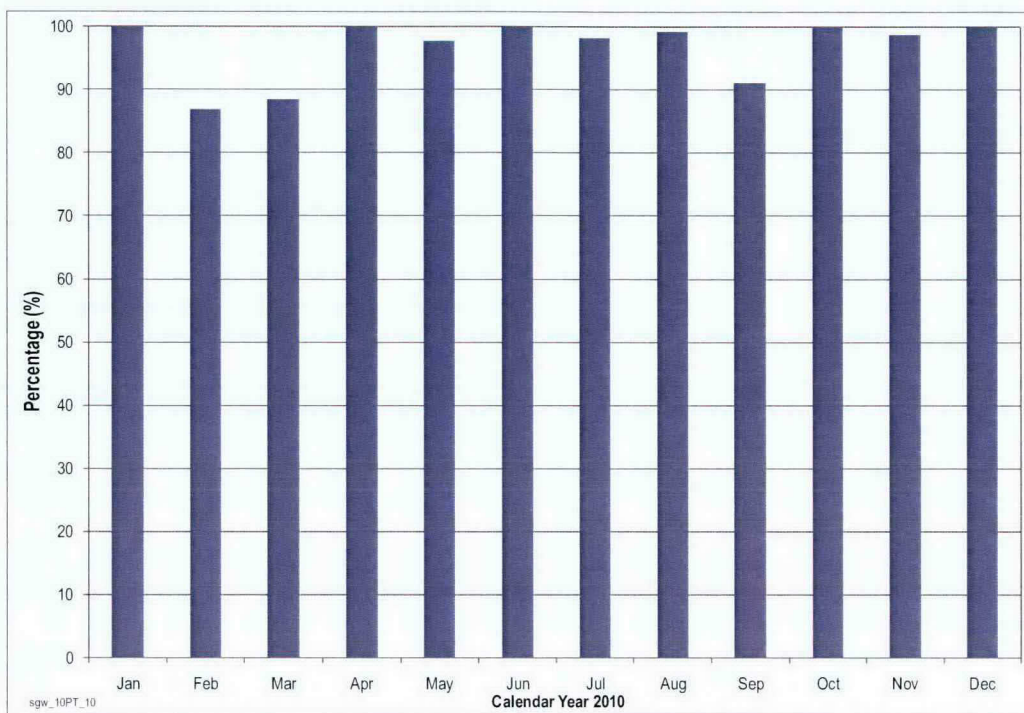


Figure 3-25. Monthly KX P&T System Availability, CY 2010

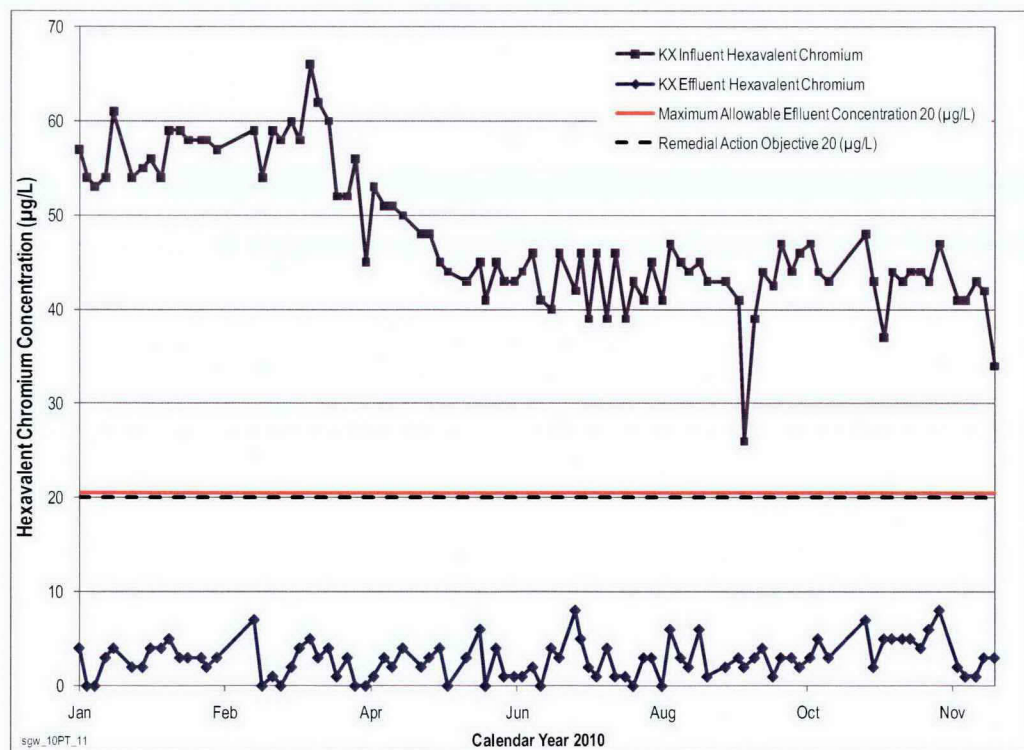
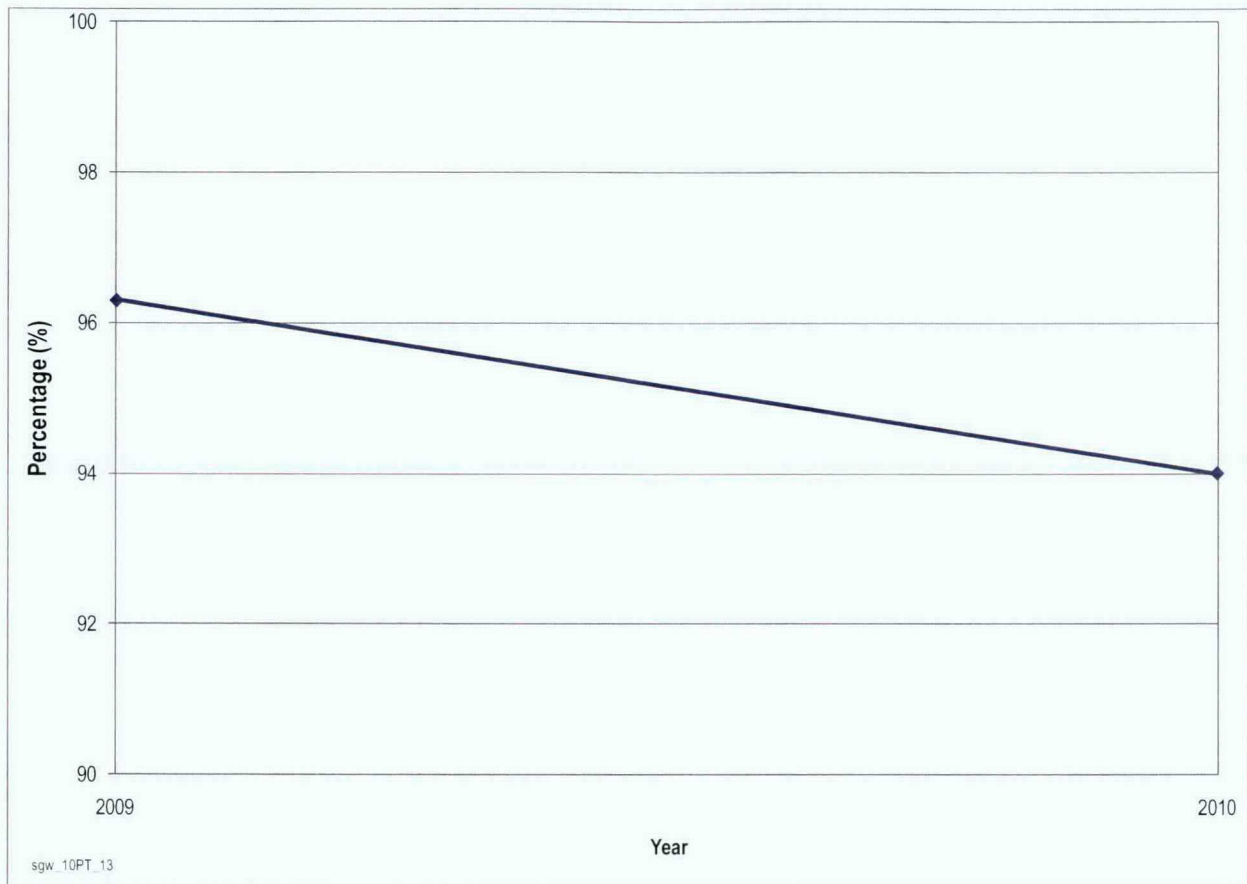


Figure 3-26. KX P&T System Trends of Influent and Effluent Hexavalent Chromium Concentrations, CY 2010



Note: Average removal efficiency (% by mass) =  $[(\text{influent} - \text{effluent}) / \text{influent}]$ .

**Figure 3-27. KX P&T System Average Removal Efficiencies**

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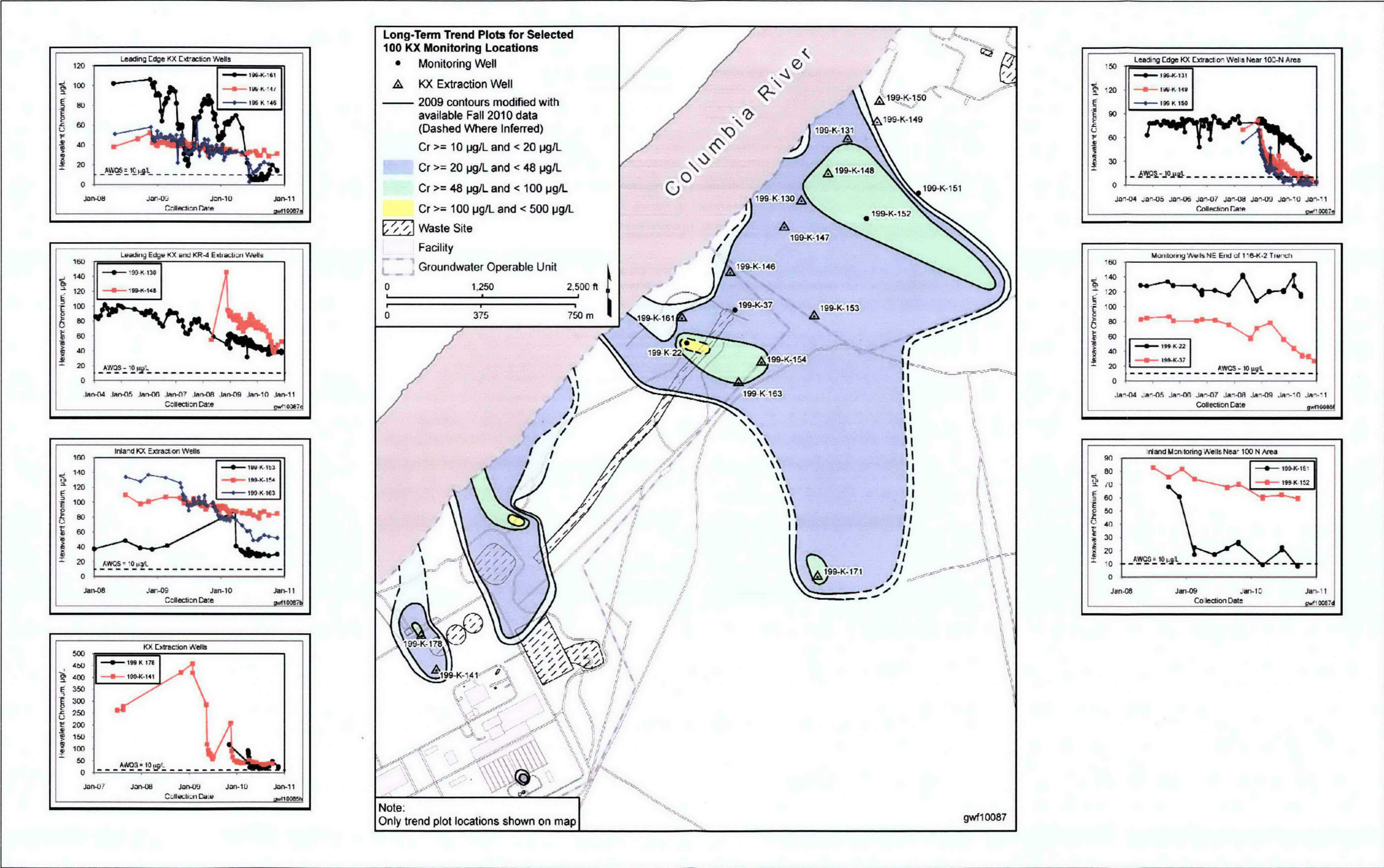


Figure 3-28. Hexavalent Chromium Concentration Trend Plots for Selected KX P&T System Monitoring Locations

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Table 3-1. 116-K-2 Trench Area (KR4 and K North Plumes) Hexavalent Chromium Concentrations, CY 2008 to CY 2010

Well or Aquifer Tube Name	Current Well Use and P&T System	Fall 2008, Filt. and Unfilt. Cr <sup>+6</sup>		Fall 2009 Sample, Unfiltered Cr <sup>+6</sup>		Fall 2010 Sample, Unfiltered Cr <sup>+6</sup>		% Change in Cr <sup>+6</sup> Conc. (Negative = Increase)	
		Date Collected	Conc. (µg/L)	Date Collected	Unfilt. Cr <sup>+6</sup> (µg/L)	Date Collected	Unfilt. Cr <sup>+6</sup> (µg/L)	2008 to 2010	2009 to 2010
199-K-18	C	10/23/08	156	10/22/09	192	12/8/10	139	10.9	27.6
199-K-19	P	10/23/08	28.7	10/18/09	13.7	12/3/10	7.3	74.6	46.7
199-K-20	C	10/27/08	5.5	10/28/09	2.3 (B)	--	--	--	--
199-K-21	P	10/23/08	6.7	10/18/09	6 (N)	12/3/10	5.5	17.9	8.3
199-K-22	P	10/23/08	108	10/22/09	120	--	--	--	--
199-K-37	P	10/27/08	71.2	10/22/09	56.7	12/3/10	27.1	61.9	52.2
199-K-111A	P	--	--	10/21/09	30.0	12/7/10	46.4	--	-54.7
199-K-113A	E/C-KR4	10/6/08	64	10/21/09	58	9/8/10	3	95.3	94.8
199-K-114A	E/C-KR4	10/6/08	85	10/21/09	62.9	--	--	--	--
199-K-115A	E/C-KR4	10/62008	91	10/21/09	84.4	9/8/10	17	81.3	79.9
199-K-116A	E/C-KR4	12/1/08	54.5	10/21/09	25.3	--	--	--	--
199-K-117A	C	10/6/08	2 (U)	10/22/09	2 (U)	12/3/10	2 (U)	NC	NC
199-K-119A	P-KR4	11/4/08	7	--	--	12/8/10	2 (U)	Dec.	--
199-K-120A	E/C-KR4	11/4/08	38	--	--	10/4/10	9	94.7	--
199-K-125A	C	11/4/08	12	--	--	--	--	--	--
199-K-126	M	--	--	10/21/09	36.6	9/22/10	27.2	--	25.7
199-K-127	E/C-KR4	11/4/08	14	--	--	10/4/10	7	50.0	--
199-K-129/K-112A	E/C-KR4	11/4/08	43	10/21/09	45.2	9/8/10	22	48.8	51.3
199-K-130	E/C-KX	11/18/08	49	10/20/09	49.7	11/22/10	37.5	23.5	24.5

Table 3-1. 116-K-2 Trench Area (KR4 and K North Plumes) Hexavalent Chromium Concentrations, CY 2008 to CY 2010

Well or Aquifer Tube Name	Current Well Use and P&T System	Fall 2008, Filt. and Unfilt. Cr <sup>+6</sup>		Fall 2009 Sample, Unfiltered Cr <sup>+6</sup>		Fall 2010 Sample, Unfiltered Cr <sup>+6</sup>		% Change in Cr <sup>+6</sup> Conc. (Negative = Increase)	
		Date Collected	Conc. (µg/L)	Date Collected	Unfilt. Cr <sup>+6</sup> (µg/L)	Date Collected	Unfilt. Cr <sup>+6</sup> (µg/L)	2008 to 2010	2009 to 2010
199-K-131	E/C-KX	11/18/08	79	10/20/09	58	9/7/10	37	53.2	36.2
699-78-62	M	--	--	--	--	--	--	--	--
199-K-121A	I-KR4	--	--	--	--	--	--	--	--
199-K-122A	I-KR4	--	--	--	--	--	--	--	--
199-K-123A	I-KR4	--	--	--	--	--	--	--	--
199-K-124A	I-KR4	--	--	--	--	12/7/10	6.1	--	--
199-K-128	I-KR4	--	--	--	--	--	--	--	--
199-K-143	I-KR4	--	--	--	--	--	--	--	--
199-K-144	E/C-KR4	10/7/08	34	--	--	10/4/10	25	26.5	--
199-K-145	E/C-KR4	11/20/08	37	12/7/09	59	10/4/10	62	-67.6	-5.1
199-K-146	E/C-KX	11/24/08	58	10/20/09	44.8	10/4/10	21	63.8	53.1
199-K-147	E/C-KX	11/19/08	52	10/20/09	37.9	11/22/10	31.5	39.4	16.9
199-K-148	E/C-KX	11/12/08	146	10/20/09	85.3	11/22/10	52.6	64.0	38.3
199-K-149	E/C-KX	11/13/08	82	10/20/09	27.2	10/25/10	8	90.2	70.6
199-K-150	E/C-KX	11/19/08	70	10/20/09	8.8	10/11/10	2	97.1	77.3
199-K-151	P	11/24/08	60.7	10/22/09	26.4	9/20/10	7.9	87.0	70.1
199-K-152	P	9/24/08	75.5	10/22/09	69.9	9/21/10	59.4	21.3	15.0
199-K-153	M	9/24/08	38.4	--	--	11/22/10	30.2	21.4	--
199-K-154	E/C-KX	9/24/08	97.5	10/12/09	94	11/22/10	85.2	12.6	9.4
199-K-156	I-KX	--	--	--	--	--	--	--	--

Table 3-1. 116-K-2 Trench Area (KR4 and K North Plumes) Hexavalent Chromium Concentrations, CY 2008 to CY 2010

Well or Aquifer Tube Name	Current Well Use and P&T System	Fall 2008, Filt. and Unfilt. Cr <sup>+6</sup>		Fall 2009 Sample, Unfiltered Cr <sup>+6</sup>		Fall 2010 Sample, Unfiltered Cr <sup>+6</sup>		% Change in Cr <sup>+6</sup> Conc. (Negative = Increase)	
		Date Collected	Conc. (µg/L)	Date Collected	Unfilt. Cr <sup>+6</sup> (µg/L)	Date Collected	Unfilt. Cr <sup>+6</sup> (µg/L)	2008 to 2010	2009 to 2010
199-K-157	P	9/24/08	64	10/29/09	51.5	12/7/10	30.2	52.8	41.4
199-K-159	I-KX	--	--	--	--	--	--	--	--
199-K-160	I-KX	--	--	--	--	--	--	--	--
199-K-161	E/C-KX	11/19/08	106	10/21/09	85.9	11/22/10	14.1	86.7	83.6
199-K-162	E/C-KR4	--	--	--	--	9/14/10	8	--	--
199-K-163	E/C-KX	9/24/08	128	10/12/09	96	11/22/10	52.2	59.2	45.6
199-K-164	I-KX	--	--	--	--	--	--	--	--
199-K-169	I-KX	--	--	--	--	--	--	--	--
199-K-170	I-KX	--	--	--	--	--	--	--	--
199-K-171	E-KX	9/5/08	79	--	--	11/22/10	53	32.9	--
199-K-172	I-KX	9/5/08	15	--	--	--	--	--	--
199-K-179	I-KX	--	--	--	--	--	--	--	--
199-K-180	I-KX	--	--	--	--	--	--	--	--
199-K-182	P	--	--	--	--	--	--	--	--
199-N-16	P	--	--	--	--	--	--	--	--
199-N-71	P	--	--	--	--	--	--	--	--
199-N-72	P	--	--	--	--	--	--	--	--
19-D	AT	--	--	11/17/09	2 (U)	--	--	--	--
21-M	AT	--	--	11/18/09	2 (U)	--	--	--	--
22-M/D	AT	--	--	11/21/09	7	--	--	--	--

Table 3-1. 116-K-2 Trench Area (KR4 and K North Plumes) Hexavalent Chromium Concentrations, CY 2008 to CY 2010

Well or Aquifer Tube Name	Current Well Use and P&T System	Fall 2008, Filt. and Unfilt. Cr <sup>+6</sup>		Fall 2009 Sample, Unfiltered Cr <sup>+6</sup>		Fall 2010 Sample, Unfiltered Cr <sup>+6</sup>		% Change in Cr <sup>+6</sup> Conc. (Negative = Increase)	
		Date Collected	Conc. (µg/L)	Date Collected	Unfilt. Cr <sup>+6</sup> (µg/L)	Date Collected	Unfilt. Cr <sup>+6</sup> (µg/L)	2008 to 2010	2009 to 2010
23-D	AT	--	--	11/23/09	2 (U)	--	--	--	--
26-D	AT	--	--	--	--	--	--	--	--
C6246	AT	--	--	11/16/09	16	--	--	--	--
C6249	AT	--	--	11/17/09	20	--	--	--	--
C6250	AT	--	--	11/17/09	24.5	--	--	--	--
C6251	AT	--	--	11/21/09	3.5 (B)	--	--	--	--
C6252	AT	--	--	11/21/09	2.3 (B)	--	--	--	--
C6253	AT	--	--	11/21/09	49.4	--	--	--	--
C6254	AT	--	--	11/21/09	2 (U)	--	--	--	--
C6255	AT	--	--	11/21/09	5.4	--	--	--	--
C6256	AT	--	--	11/21/09	30.1	--	--	--	--
C6257	AT	--	--	11/21/09	2 (U)	--	--	--	--
C6258	AT	--	--	11/21/09	2 (U)	--	--	--	--
C6259	AT			11/21/09	2 (U)				
C6260	AT	--	--	11/23/09	2 (U)	--	--	--	--
C6263	AT	--	--	11/21/09	2 (U)	12/28/10	2 (U)	--	--
C6264	AT	--	--	11/21/09	2 (U)	12/28/10	2 (U)	--	--
C6265	AT	--	--	11/21/09	2 (U)	12/28/10	2 (U)	--	--
DK-04-2	AT	--	--	11/21/09	2 (U)	--	--	--	--
AT-K-3-D	AT	--	--	11/01/09	62.8	12/17/10	56.9	--	-9.3

Table 3-1. 116-K-2 Trench Area (KR4 and K North Plumes) Hexavalent Chromium Concentrations, CY 2008 to CY 2010

Well or Aquifer Tube Name	Current Well Use and P&T System	Fall 2008, Filt. and Unfilt. Cr <sup>+6</sup>		Fall 2009 Sample, Unfiltered Cr <sup>+6</sup>		Fall 2010 Sample, Unfiltered Cr <sup>+6</sup>		% Change in Cr <sup>+6</sup> Conc. (Negative = Increase)	
		Date Collected	Conc. (µg/L)	Date Collected	Unfilt. Cr <sup>+6</sup> (µg/L)	Date Collected	Unfilt. Cr <sup>+6</sup> (µg/L)	2008 to 2010	2009 to 2010
AT-K-4-M	AT	--	--	11/23/09	2 (U)	--	--	--	--
AT-K-5-D	AT	--	--	11/23/09	45.6	--	--	--	--
AT-K-6-M	AT	--	--	--	--	--	--	--	--

## Notes:

1. Well use: C = compliance, E = extraction, I = injection, M = monitoring, P = performance, X = KR4 expansion well (use to be determined).
2. Abbreviations: NA = not available, NC = change in concentration not calculated because results are both nondetect, UF = unfiltered.
3. Aquifer tube nomenclature regarding relative depth: D = deepest, M = middle, and S = shallowest.
4. Change in hexavalent chromium concentration at site 22 included sample results from both the middle and deep tube in cluster because all tubes not sampled each year.
5. Change in hexavalent chromium concentration is not calculated when "U" (nondetect) values are used in the calculation. Where both values have a "U" qualifier, the values are assumed to not have changed significantly.
6. The 2007 results for injection wells are treated effluent hexavalent chromium concentrations.
7. Laboratory qualifiers: U = nondetect (shown with detection limit in parentheses), B = detected above instrument or method detection limit but below contract-required detection limit, D = sample diluted.
8. Hexavalent chromium results from well 199-K-126 have been influenced by the calcium polysulfide treatability test that changed the color of groundwater and so strongly influenced the colorimetric EPA Method 7196 results. High out-of-trend results from this well have been rejected because of lingering calcium polysulfide influence.
9. Blank cells (marked as "--") indicate that the sample was not collected, the analysis was not performed or the change in concentration was not calculated.
10. Where contaminant concentration comparisons involve one nonqualified result and one nondetect (U) result, the percent change was not calculated but rather and increase (inc.) or decrease (dec.) in concentration between years was noted.

Table 3-2. KW Plume Hexavalent Chromium Concentrations, CY 2008 to CY 2010

Well Name	Use	Fall 2008 Unfiltered Cr <sup>+6</sup>		Fall 2009 Unfiltered Cr <sup>+6</sup>		Fall 2010 Sample Unfiltered Cr <sup>+6</sup>		% Change in Cr <sup>+6</sup> Conc. (Negative = Increase)	
		Date Collected	Conc. (µg/L)	Date Collected	Conc. (µg/L)	Date Collected	Conc. (µg/L)	2008 to 2010	2009 to 2010
199-K-34	M	10/27/08	44.1	10/22/09	36.8	12/7/10	5.1	88.4	86.1
199-K-35	M	--	--	12/22/09	188	Decommissioned	--	--	199-K-35
199-K-106A	M	10/6/08	4.8	10/22/09	2.1 (B)	--	--	--	--
199-K-107A	M	10/6/08	172	10/22/09	29.3	12/3/10	14.4	91.6	50.9
199-K-108A	M	10/6/08	81.5	10/22/09	5.2	12/8/10	2(U)	Dec.	Dec.
199-K-31	M	--	--	10/22/09	5.6	12/8/10	5.6		0.0
199-K-132	E	10/23/08	41	10/20/09	20	11/22/10	16.8	59.0	16.0
199-K-137	M	10/28/08	1,390	10/26/09	211	11/1/10	109	92.2	48.3
199-K-138	E	10/28/08	40.5	10/12/09	38	11/22/10	20.6	49.1	45.8
199-K-139	E	10/31/08	124	11/10/09	117	11/15/10	25	79.8	78.6
199-K-140	E	10/28/08	14.1	10/20/09	13	--	--	--	--
199-K-165	E	11/10/08	2,530	10/20/09	232	11/15/10	321	87.3	-38.4
199-K-166	E	11/10/08	101	10/20/09	56.1	11/22/10	30.5	69.8	45.6
199-K-167	--	--	--	--	--	--	--	--	--
199-K-168	E	11/10/08	241	10/20/09	130	11/15/10	57	76.3	56.2
199-K-173	M	12/1/08	7.3	10/21/09	104	--	--	--	--
199-K-174	I	--	--	--	--	--	--	--	--
199-K-175	I	--	--	--	--	--	--	--	--

Table 3-2. KW Plume Hexavalent Chromium Concentrations, CY 2008 to CY 2010

Well Name	Use	Fall 2008 Unfiltered Cr <sup>+6</sup>		Fall 2009 Unfiltered Cr <sup>+6</sup>		Fall 2010 Sample Unfiltered Cr <sup>+6</sup>		% Change in Cr <sup>+6</sup> Conc. (Negative = Increase)	
		Date Collected	Conc. (µg/L)	Date Collected	Conc. (µg/L)	Date Collected	Conc. (µg/L)	2008 to 2010	2009 to 2010
AT-K-1	AT	--	--	11/1/09	7.5	12/17/10	2 (U)	--	74

## Notes:

1. Laboratory qualifiers: B = detected above instrument or method detection limit, but below contract-required detection limit, D = sample diluted; C = analyte detected in both the sample and the associated quality control blank, and the sample concentration was less than or equal to five times the blank concentration; U = analyte undetected and the detection limit is included within parentheses.
2. Well use: C = compliance, E = extraction, I = injection, M = monitoring.
3. Abbreviations: NA = not available, NC = not calculated, UF = unfiltered, AT = aquifer tube.
4. Aquifer tube nomenclature regarding relative depth: D = deepest, M = middle, S = shallowest.
5. Change in hexavalent chromium concentration at site AT-K-1 included sample results from both the middle and deep tube in cluster because all tubes not sampled each year.
6. Blank cells indicate that the sample was not collected, the analysis was not performed, or the change in concentration was not calculated.
7. Where contaminant concentration comparisons involve one non-qualified result and one nondetect (U) result, the percent change was not calculated but rather an increase (inc.) or decrease (dec.) in concentration between years was noted.

Table 3-3. KE Reactor Area Plume, Hexavalent Chromium Concentrations, CY 2008 to CY 2010

Well Name	Use	Fall 2008 Unfilt. Cr <sup>+6</sup>		Fall 2009 Unfilt. Cr <sup>+6</sup>		Fall 2010 Sample Unfilt. Cr <sup>+6</sup>		% Change in Cr <sup>+6</sup> Conc. (Negative = Increase)	
		Date Collected	Conc. (µg/L)	Date Collected	Conc. (µg/L)	Date Collected	Conc. (µg/L)	2008 to 2010	2009 to 2010
199-K-32A	P	10/27/08	13.1	10/22/09	11.8	12/3/10	8.3	36.6	29.7
199-K-32B	M	10/27/08	6.8	10/18/09	5.1	12/8/10	2.9 (B)	57.4	43.1
199-K-30	M	10/27/08	3.3	10/18/09	2.1 (B)	12/2/10	7.5	-127.3	-257.1
199-K-29	M	--	--	--	--	12/2/10	2 (U)	--	--
199-K-23	M	10/27/08	2 (U)	--	--	--	--	--	--
199-K-11	M	10/6/08	2 (U)	10/28/09	2 (U)	12/3/10	5.3	Inc.	Inc.
199-K-110A	M	--	--	10/18/09	2 (U)	12/8/10	2 (U)	NC	NC
199-K-36	M	10/27/08	21.4	10/22/09	20.0	12/3/10	34.2	-59.8	-71.0
199-K-141	E-KX	10/28/08	421	11/23/09	91	10/4/10	38	91.0	58.2
199-K-142	M	10/28/08	5.8	10/22/09	3.3 (B)	12/8/10	4	31.0	-21.2
199-K-178	E-KX	--	--	11/5/09	117	11/17/10	23.8	--	79.7
199-K-181	C	--	--	11/5/09	8.6	--	--	--	--
C6242	AT	--	--	11/18/09	2 (U)	--	--	--	--
C6243	AT	--	--	11/18/09	4.8 (B)	--	--	--	--
C6244	AT	--	--	11/18/09	5.2	--	--	--	--
C6245	AT	--	--	11/16/09	14.8	--	--	--	--
C6246	AT	--	--	11/16/09	16	--	--	--	--
C6247	AT	--	--	11/16/09	15.7	--	--	--	--
19-D	AT	--	--	11/17/09	2 (U)	--	--	--	--
AT-K-2-D	AT	--	--	11/1/09	3.4 (B)	12/17/10	2 (U)	--	41.2

**Table 3-3. KE Reactor Area Plume, Hexavalent Chromium Concentrations, CY 2008 to CY 2010**

Well Name	Use	Fall 2008 Unfilt. Cr <sup>+6</sup>		Fall 2009 Unfilt. Cr <sup>+6</sup>		Fall 2010 Sample Unfilt. Cr <sup>+6</sup>		% Change in Cr <sup>+6</sup> Conc. (Negative = Increase)	
		Date Collected	Conc. (µg/L)	Date Collected	Conc. (µg/L)	Date Collected	Conc. (µg/L)	2008 to 2010	2009 to 2010

## Notes:

1. Laboratory qualifiers: B = detected above instrument or method detection limit, but below contract-required detection limit; D = sample diluted; C = analyte detected in both the sample and the associated quality control blank, and the sample concentration was less than or equal to five times the blank concentration; U = analyte nondetect and the detection limit is included within parentheses.
2. Well use: C = compliance, E = extraction, I = injection, M = monitoring, P = performance.
3. Abbreviations: NA = not available, NC = not calculated, UF = unfiltered, AT=aquifer tube.
4. Aquifer tube nomenclature regarding relative depth: D = deepest, M = middle, S = shallowest.
5. Change in hexavalent chromium concentration at site AT-K-1 included sample results from both the middle and deep tube in cluster because all tubes not sampled each year.
6. Blank cells (marked as "--") indicate that the sample was not collected, the analysis was not performed or the change in concentration was not calculated.
7. Where contaminant concentration comparisons involve one non qualified result and one nondetect (U) result, the percent change was not calculated, but rather an increase (inc.) or decrease (dec.) in concentration between years was noted.

**Table 3-4. Tritium Activity in 116-K-2 Trench and K North Area Wells and Aquifer Tubes, 2008 to 2010**

Well or Aquifer Tube Name	Use	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		% Change in Concentration (Negative =increase)	
		Date Collected	Tritium (pCi/L)	Date Collected	Tritium (pCi/L)	Date Collected	Tritium (pCi/L)	2008 to 2010	2009 to 2010
199-K-18	C	10/23/08	29000	10/22/09	43,000	--	--	--	--
199-K-19	P	10/23/08	2,900	10/18/09	3,900	12/3/10	4,800	-65.5	-23.1
199-K-20	C	10/27/08	5,400	10/28/09	6,100	--	--	--	--
199-K-21	P	10/23/08	240	10/18/09	5,800	12/3/10	58 (U)	Dec.	Dec.
199-K-22	P	10/23/08	250	10/22/09	27 (U)	--	--	--	--
199-K-37	P	10/27/08	188 (U)	10/22/09	680	12/3/10	300	-59.6	55.9
199-K-113A	E/C-KR4	--	--	10/21/09	170 (U)	--	--	--	--
199-K-114A	E/C-KR4	--	--	10/21/09	50 (U)	--	--	--	--
199-K-115A	E/C-KR4	--	--	10/21/09	56 (U)	--	--	--	--
199-K-116A	E/C-KR4	--	--	10/21/09	4,600	--	--	--	--
199-K-117A	C	10/6/08	200 (U)	10/22/09	41 (U)	12/3/10	-29 (U)	NC	NC
199-K-119A	E/C-KR4	--	--	--	--	12/8/10	6,700		
199-K-120A	E/C-KR4	--	--	--	--	--	--	--	--
199-K-118A/125A	C	--	--	--	--	--	--	--	--
199-K-126	M	--	--	--	--	--	--	--	--
199-K-127	E/C-KR4	--	--	--	--	--	--	--	--
199-K-129/K-112A	E/C-KR4	--	--	10/21/09	-22 (U)	--	--	--	--
199-K-130	E/C-KX	--	--	10/20/09	2,500	11/22/10	1,900	--	24.0
199-K-131	E/C-KX	--	--	10/20/09	3,300	--	--	--	--
699-78-62	M	11/23/08	1,700	11/23/08	1,700	--	--	--	--

Table 3-4. Tritium Activity in 116-K-2 Trench and K North Area Wells and Aquifer Tubes, 2008 to 2010

Well or Aquifer Tube Name	Use	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		% Change in Concentration (Negative =increase)	
		Date Collected	Tritium (pCi/L)	Date Collected	Tritium (pCi/L)	Date Collected	Tritium (pCi/L)	2008 to 2010	2009 to 2010
199-K-121A	I-KR4	--	--	--	--	--	--	--	--
199-K-122A	I-KR4	--	--	--	--	--	--	--	--
199-K-123A	I-KR4	--	--	--	--	--	--	--	--
199-K-124A	I-KR4	--	--	--	--	12/7/10	6,900	--	--
199-K-128A	I-KR4	--	--	--	--	--	--	--	--
199-K-144	E/C-KR4	10/7/08	200,000	--	--	--	--	--	--
199-K-145	E/C-KR4	--	--	--	--	--	--	--	--
199-K-146	E/C-KX	--	--	10/20/09	150 (U)	--	--	--	--
199-K-147	E/C-KX	--	--	10/20/09	2,100	11/22/10	810	--	61.4
199-K-148	E/C-KX	--	--	10/20/09	3,800	11/22/10	2,500	--	34.2
199-K-149	E/C-KX	--	--	10/20/09	1,900	--	--	--	--
199-K-150	E/C-KX	--	--	10/20/09	7,800	--	--	--	--
199-K-151	P	11/24/08	4,500	10/22/09	1,200	9/20/10	940	79.1	21.7
199-K-152	P	12/8/08	800	10/22/09	280	9/21/10	150 (U)	81.3	46.4
199-K-153	M	12/1/08	0.9 (U)	--	--	11/22/10	740	--	--
199-K-154	E-KX	9/24/08	58.7 (U)	11/9/08	32 (U)	11/22/10	190 (U)	NC	NC
199-K-156	I-KX	--	--	--	--	--	--	--	--
199-K-157	P	11/18/08	320,000	10/29/09	290,000	12/7/10	27,000	91.6	90.7
199-K-159	I-KX	--	--	--	--	--	--	--	--
199-K-160	I-KX	--	--	--	--	--	--	--	--

Table 3-4. Tritium Activity in 116-K-2 Trench and K North Area Wells and Aquifer Tubes, 2008 to 2010

Well or Aquifer Tube Name	Use	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		% Change in Concentration (Negative =increase)	
		Date Collected	Tritium (pCi/L)	Date Collected	Tritium (pCi/L)	Date Collected	Tritium (pCi/L)	2008 to 2010	2009 to 2010
199-K-161	E/C-KX	--	--	10/21/09	108 (U)	11/22/10	83 (U)	--	NC
199-K-162	E/C-KR4	--	--	--	--	--	--	--	--
199-K-163	E/C-KX	11/9/08	203 (U)	--	--	11/22/10	5,200	Inc.	--
199-K-164	I-KX	--	--	--	--	--	--	--	--
199-K-169	I-KX	--	--	--	--	--	--	--	--
199-K-170	I-KX	--	--	--	--	--	--	--	--
199-K-171	E-KX	9/5/08	670	--	--	11/22/10	2,300	-243.3	--
199-K-172	I-KX	9/5/08	-9.5 (U)	--	--	--	--	--	--
199-K-179	I-KX	--	--	11/5/09	7,500	--	--	--	--
199-K-180	I-KX	--	--	--	--	--	--	--	--
199-K-182	P	--	--	12/28/09	5,800	9/20/10	4,100	--	29.3
199-N-16	P	--	--	10/18/09	300	--	--	--	--
199-N-72	P	--	--	--	--	--	--	--	--
199-N-71	P	--	--	10/21/09	1,050	--	--	--	--
19-D/M	AT	--	--	11/17/09	130 (U)	--	--	--	--
21-M	AT	--	--	11/18/09	100 (U)	--	--	--	--
22-M/D	AT	--	--	11/21/09	71 (U)	--	--	--	--
23-D	AT	--	--	11/23/09	-220 (U)	--	--	--	--
26-D	AT	--	--	8/19/08	1,900	--	--	--	--
C6246	AT	--	--	--	--	--	--	--	--

Table 3-4. Tritium Activity in 116-K-2 Trench and K North Area Wells and Aquifer Tubes, 2008 to 2010

Well or Aquifer Tube Name	Use	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		% Change in Concentration (Negative =increase)	
		Date Collected	Tritium (pCi/L)	Date Collected	Tritium (pCi/L)	Date Collected	Tritium (pCi/L)	2008 to 2010	2009 to 2010
C6250	AT	--	--	11/17/09	1,700	--	--	--	--
C6253	AT	--	--	11/21/09	620	--	--	--	--
C6256	AT	--	--	11/21/09	240	--	--	--	--
C6259	AT	--	--	11/21/09	730	--	--	--	--
C6260	AT	--	--	--	--	--	--	--	--
DK-04-2	AT	--	--	11/21/09	620	--	--	--	--
AT-K-3-D/M	AT	--	--	11/1/09	5,400	--	--	--	--
AT-K-4-M	AT	--	--	11/23/09	37 (U)	--	--	--	--
AT-K-5-D/M	AT	--	--	11/23/09	300	--	--	--	--
AT-K-6-M	AT	--	--	--	--	--	--	--	--

## Notes:

1. Well use: C = compliance, E = extraction, I = injection, M = monitoring, P = performance, AT = aquifer tube.
2. Aquifer tube nomenclature indicates relative depth: D = deepest, M = middle, S = shallowest.
3. Abbreviations: N/A = not available, NC = not calculated, NS = not sampled.
4. Change in tritium concentration at some aquifer tube clusters may include sample results from both the middle and deep tube in cluster because all tubes not sampled each year.
5. Laboratory qualifiers: J = value reported is an estimate, U = nondetect in sample above detection limit.
6. Change in tritium concentration not calculated (NC) when both values include "U" (nondetect) qualifier. If one value has a "U" qualifier and the second value is unqualified, the change in concentration is shown as increase (inc) or decrease (dec).
7. November 2007 tritium concentrations in injection wells represent samples of treated effluent.

Table 3-5. Tritium Activity KW Reactor Area in Wells and Aquifer Tubes, 2008 to 2010

Well Name	Use	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		% Change in Concentration (Negative = Increase)	
		Date Collected	Tritium (pCi/L)	Date Collected	Tritium (pCi/L)	Date Collected	Tritium (pCi/L)	2008 to 2010	2009 to 2010
199-K-34	P	10/27/08	1,300	10/22/09	4,400	9/20/10	4,100	-215.4	6.8
199-K-35	I	--	--	--	--	--	--	--	--
199-K-106A	P	10/6/08	21,000	10/22/09	2,300	9/13/10	3,200	84.8	-39.1
199-K-107A	P	10/6/08	760	10/18/09	1,200	12/3/10	1,300	-71.1	-8.3
199-K-108A	P	10/6/08	920	10/22/09	220 (U)	--	--	--	--
199-K-31	M	10/27/08	1,300	10/22/09	1,500	12/8/10	1,600	-23.1	-6.7
199-K-132	E	10/28/08	6,000	10/20/09	8,200	11/22/10	7,500	-25.0	8.5
199-K-137	E	10/28/08	1,600	10/20/09	940	--	--	--	--
199-K-138	E	10/28/08	1,200	10/20/09	1,100	11/22/10	1,500	-25.0	-36.4
199-K-139	E	10/30/08	1,500	11/10/09	1,600	--	--	--	--
199-K-140	M	10/28/08	1,600	10/20/09	1,700	--	--	--	--
199-K-165	E	11/10/08	684	10/20/09	970	--	--	--	--
199-K-166	E	11/10/08	1,190	10/20/09	2,600	11/22/10	1,400	-17.6	46.2
199-K-167	Aband.	--	--	--	--	--	--	--	--
199-K-168	E	10/29/08	1,370	10/20/09	970	--	--	--	--
199-K-173	P	9/27/08	910	10/21/09	1,200	--	--	--	--
199-K-174	I	--	--	--	--	--	--	--	--
199-K-175	I	--	--	--	--	--	--	--	--
AT-K-D/M	AT	--	--	11/1/09	100 (U)	--	--	--	--

**Table 3-5. Tritium Activity KW Reactor Area in Wells and Aquifer Tubes, 2008 to 2010**

Well Name	Use	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		% Change in Concentration (Negative = Increase)	
		Date Collected	Tritium (pCi/L)	Date Collected	Tritium (pCi/L)	Date Collected	Tritium (pCi/L)	2008 to 2010	2009 to 2010

Notes:

1. Well use: C = compliance, E = extraction, I = injection, M = monitoring, P = performance.
2. Abbreviations: AT = aquifer tube, NA = not available, NC = not calculated.
3. Aquifer tube nomenclature regarding relative depth: D = deepest, M = middle, S = shallowest.
4. Laboratory qualifiers: U = not detected in sample above detection limit.
5. Change in tritium concentration at site AT-K-1 included sample results from both the middle and deep tube in cluster because all tubes not sampled each year.
6. Change in tritium concentration is not calculated (NC) when two "U qualified (nondetect) values are used in calculation. When one result is not qualified and the compared result is "U" qualified, the change is shown as increase (inc.) or decrease (dec.).
7. Blank cells (marked with "--") indicate that the sample was not collected or the analysis was not performed.

Table 3-6. Tritium Activity in KE Reactor Area Wells and Aquifer Tubes, 2008 to 2010

Well Name	Use	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		Change in Nitrate Concentration (Negative = Increase)	
		Date Collected	Tritium (pCi/L)	Date Collected	Tritium (pCi/L)	Date Collected	Tritium (pCi/L)	2008 to 2010	2009 to 2010
199-K-32A	P	10/27/08	4,200	10/22/09	3,900	12/3/10	2,500	40.5	35.9
199-K-32B	M (see note 1)	10/27/08	140 (U)	10/18/09	-29 (U)	--	--	--	--
199-K-30	M	10/27/08	410,000	10/18/09	140,000	12/2/10	16,000	96.1	88.6
199-K-29	M	9/29/08	7,100	--	--	12/2/10	130,000	-1731.0	--
199-K-27	Decom.	--	--	--	--	--	--	--	--
199-K-23	M	10/27/08	120 (U)	--	--	--	--	--	--
199-K-11	M	10/6/08	140 (U)	10/28/09	66 (U)	12/3/10	330	-135.7	-400.0
199-K-109A	M	--	--	--	--	--	--	--	--
199-K-110A	M	10/6/08	160 (U)	10/18/09	96 (U)	12/8/10	140 (U)	NC	NC
199-K-111A	P	10/6/08	6,000	10/21/09	7,515	12/7/10	26,000	-333.3	-246.0
199-K-36	M	10/27/08	172 (U)	10/22/09	48.4 (U)	12/3/10	130 (U)	NC	NC
199-K-141	E-KR4	10/28/08	4,300	--	--	--	--	--	--
199-K-142	P	10/28/08	1,200	10/22/09	290	12/8/10	117 (U)	90.3	59.7
199-K-178	E-KR4	--	--	10/8/09	3,100	11/17/10	1,100	--	64.5
199-K-181	C	--	--	10/8/09	340	--	--	--	--
C6241	AT	--	--	11/15/09	550	--	--	--	--
C6244	AT	--	--	11/18/09	2,100	--	--	--	--
18-S	AT	--	--	11/18/09	160 (U)	--	--	--	--
19-D	AT	--	--	--	--	--	--	--	--

**Table 3-6. Tritium Activity in KE Reactor Area Wells and Aquifer Tubes, 2008 to 2010**

Well Name	Use	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		Change in Nitrate Concentration (Negative = Increase)	
		Date Collected	Tritium (pCi/L)	Date Collected	Tritium (pCi/L)	Date Collected	Tritium (pCi/L)	2008 to 2010	2009 to 2010
AT-K-2-M	AT	--	--	--	--	--	--	--	--

Notes:

1. Well 199-K-32B is screened within the RUM, and well 199-K-32A is screened within the Ringold unit E.
2. Well and aquifer tube use: M = monitoring, AT = aquifer tube, P = performance, E= extraction.
3. Aquifer tube nomenclature regarding relative depth: D = deepest, M = middle, S = shallowest.
4. Laboratory qualifiers: J = reported value is an estimate, U = not detected in sample above detection limit.
5. Change in tritium concentration is not calculated (NC) when both results include "U" (nondetect) qualifiers. If one compared result includes a "U" qualifier and the second is unqualified, the change in concentration is shown as increase (inc.) or decrease (dec.).
6. Blank cells (marked with "--") indicate that the sample was not collected or the analysis was not performed.

Table 3-7. Strontium-90 Activity in 116-K-2 Trench and 100-N Area Wells and Aquifer Tubes, 2008 to 2010

Well or Aquifer Tube Name	Current Use and P&T System	Fall 2008		Fall 2009		Fall 2010		Change in Sr-90 Conc.	
		Date Collected	Sr-90 (pCi/L)	Date Collected	Sr-90 (pCi/L)	Date Collected	Sr-90 (pCi/L)	2008 to 2010 (%) (Negative = Increase)	2009 to 2010 (%) (Negative = Increase)
199-K-18	C	10/23/08	-1.38 (U)	10/22/09	-6 (U)	--	--	--	--
199-K-19	P	--	--	10/18/09	7.5	12/3/10	12	--	-60.0
199-K-20	C	10/27/08	3.05	10/28/09	-1.5 (U)	--	--	--	--
199-K-21	P	10/23/08	26.7	10/18/09	22	12/3/10	17	36.3	22.7
199-K-22	P	10/23/08	6.78	10/22/09	-4.2 (U)	--	--	--	--
199-K-37	P	--	--	10/22/09	-7.7 (U)	12/3/10	-3.1 (U)	--	NC
199-K-113A	E/C-KR4	--	--	10/21/09	5.9	--	--	--	--
199-K-114A	E/C-KR4	--	--	10/21/09	8.7	--	--	--	--
199-K-115A	E/C-KR4	--	--	10/21/09	6.1	--	--	--	--
199-K-116A	E/C-KR4	--	--	10/21/09	1.4	--	--	--	--
199-K-117A	C	10/6/08	0.18 (U)	10/22/09	-3.1 (U)	12/3/10	-1.2 (U)	NC	NC
199-K-119A	E/C-KR4	--	--	--	--	12/8/10	1.2 (U)	--	--
199-K-120A	E/C-KR4	--	--	--	--	--	--	--	--
199-K-125A	C	--	--	--	--	--	--	--	--
199-K-127	M	--	--	--	--	--	--	--	--
199-K-129/ 199-K-112A	E/C-KR4	--	--	10/21/09	-0.1 (U)	--	--	--	--
199-K-130	E/C-KR4	--	--	10/20/09	0.1 (U)	11/22/10	-11 (U)	--	NC
199-K-131	E/C-KX	--	--	10/20/09	-3 (U)	--	--	--	--
699-78-62	E/C-KX	--	--	--	--	--	--	--	--

Table 3-7. Strontium-90 Activity in 116-K-2 Trench and 100-N Area Wells and Aquifer Tubes, 2008 to 2010

Well or Aquifer Tube Name	Current Use and P&T System	Fall 2008		Fall 2009		Fall 2010		Change in Sr-90 Conc.	
		Date Collected	Sr-90 (pCi/L)	Date Collected	Sr-90 (pCi/L)	Date Collected	Sr-90 (pCi/L)	2008 to 2010 (%) (Negative = Increase)	2009 to 2010 (%) (Negative = Increase)
199-K-121A	I-KR4	--	--	--	--	--	--	--	--
199-K-122A	I-KR4	--	--	--	--	--	--	--	--
199-K-123A	I-KR4	--	--	--	--	--	--	--	--
199-K-124A	I-KR4	--	--	--	--	12/7/10	-0.18	--	--
199-K-143	I-KR4	--	--	--	--	--	--	--	--
199-K-144	E/C-KR4	--	--	--	--	--	--	--	--
199-K-145	E/C-KR4	--	--	--	--	--	--	--	--
199-K-146	E/C-KX	--	--	10/20/09	-2.5	--	--	--	--
199-K-147	E/C-KX	--	--	10/20/09	4.4	11/22/10	-4.9 (U)		NC
199-K-148	E/C-KX	--	--	10/20/09	0.69	11/22/10	-7.2 (U)		Dec.
199-K-149	E/C-KX	--	--	10/20/09	-5.1 (U)	--	--	--	--
199-K-150	E/C-KX	--	--	10/20/09	-2.8 (U)	--	--	--	--
199-K-151	P	11/28/08	-7.2 (U)	10/22/09	-6.4 (U)	9/20/10	-4.7 (U)	--	NC
199-K-152	P	9/24/08	3	10/22/09	-7.2 (U)	9/21/10	-5.5 (U)	--	NC
199-K-153	M	9/24/08	-1.2 (U)	--	--	11/22/10	-10 (U)	--	--
199-K-154	E-KX	9/24/08	0.53 (U)	--	--	11/22/10	-8.1 (U)	--	--
199-K-156	I-KX	--	--	--	--	--	--	--	--
199-K-157	P	11/18/08	0.6 (U)	10/29/09	2.6	12/7/10	-0.45 (U)	NC	dec
199-K-159	I-KX	--	--	--	--	--	--	--	--
199-K-160	I-KX	--	--	--	--	--	--	--	--

Table 3-7. Strontium-90 Activity in 116-K-2 Trench and 100-N Area Wells and Aquifer Tubes, 2008 to 2010

Well or Aquifer Tube Name	Current Use and P&T System	Fall 2008		Fall 2009		Fall 2010		Change in Sr-90 Conc.	
		Date Collected	Sr-90 (pCi/L)	Date Collected	Sr-90 (pCi/L)	Date Collected	Sr-90 (pCi/L)	2008 to 2010 (%) (Negative = Increase)	2009 to 2010 (%) (Negative = Increase)
199-K-161	E/C-KX	--	--	10/21/09	14.8	11/22/10	-2.2 (U)	--	--
199-K-162	E/C-KR4	--	--	--	--	--	--	--	--
199-K-163	E/C-KX	11/9/08	-0.953 (U)	--	--	11/22/10	-6.7 (U)	NC	--
199-K-164	I-KX	--	--	--	--	--	--	--	--
199-K-169	I-KX	--	--	--	--	--	--	--	--
199-K-170	I-KX	--	--	--	--	--	--	--	--
199-K-171	E-KX	9/5/08	-0.49 (U)	--	--	11/22/10	-7.2 (U)	NC	--
199-K-172	I-KX	9/5/08	-2 (U)	--	--	--	--	--	--
199-K-179	I-KX	--	--	11/5/09	-5.5 (U)	--	--	--	--
199-K-180	I-KX	--	--	--	--	--	--	--	--
199-K-182	P	--	--	--	--	9/20/10	-1.8 (U)	--	--
19-D/M	AT	--	--	11/17/09	-1 (U)	--	--	--	--
21-M	AT	--	--	11/18/09	2.1 (U)	--	--	--	--
22-M/D	AT	--	--	--	--	--	--	--	--
23-D	AT	--	--	--	--	--	--	--	--
C6246	AT	--	--	11/16/09	-2.7 (U)	--	--	--	--
C6250	AT	--	--	--	--	--	--	--	--
C6253	AT	--	--	--	--	--	--	--	--
C6256	AT	--	--	11/21/09	-4.5 (U)	--	--	--	--
C6259	AT	--	--	11/21/09	-7 (U)	--	--	--	--

Table 3-7. Strontium-90 Activity in 116-K-2 Trench and 100-N Area Wells and Aquifer Tubes, 2008 to 2010

Well or Aquifer Tube Name	Current Use and P&T System	Fall 2008		Fall 2009		Fall 2010		Change in Sr-90 Conc.	
		Date Collected	Sr-90 (pCi/L)	Date Collected	Sr-90 (pCi/L)	Date Collected	Sr-90 (pCi/L)	2008 to 2010 (%) (Negative = Increase)	2009 to 2010 (%) (Negative = Increase)
C6260	AT	--	--	--	--	--	--	--	--
DK-04-2	AT	--	--	--	--	--	--	--	--
AT-K-3-D/M	AT	--	--	11/17/09	-1.7 (U)	--	--	--	--
AT-K-4-M	AT	--	--	11/23/09	-9.2 (U)	--	--	--	--
AT-K-5-D/M	AT	--	--	11/23/09	0.14 (U)	--	--	--	--
AT-K-6-M	AT	--	--	--	--	--	--	--	--

## Notes:

1. Well use: C = compliance, E = extraction, I = injection, M = monitoring, P = performance, AT = aquifer tube.
2. Abbreviations: NA = not available, NC = not calculated, NS = not sampled.
3. Aquifer tube nomenclature indicates relative depth: D = deepest, m = middle, S = shallowest.
4. Laboratory qualifiers: U = nondetect, J = value reported is estimated.
5. Change in strontium-90 concentration at some aquifer tube clusters may include sample results from both the middle and deep tube in cluster because all tubes not sampled each year.
6. Change in strontium-90 concentration not calculated when "U" (nondetect) values are compared (NC).
7. Blank cells (marked with "--") indicate that the sample was not collected, the analysis was not performed
8. Where contaminant concentration comparisons involve one nonqualified result and one nondetect (U) result, the percent change was not calculated but rather and increase (inc.) or decrease (dec.) in concentration between years was noted.

Table 3-8. Strontium-90 Activity in KW Reactor Area Wells and Aquifer Tubes, 2008 to 2010

Well Name	Use	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		% Change in Sr-90 Concentration (Negative = Increase)	
		Date Collected	Sr-90 (pCi/L)	Date Collected	Sr-90 (pCi/L)	Date Collected	Sr-90 (pCi/L)	2008 to 2010	2009 to 2010
199-K-34	P	10/27/08	36.4	10/22/09	16	12/7/10	45	-23.6	-181
199-K-35	I	--	--	--	--	--	--	--	--
199-K-106A	P	--	--	10/22/09	6.3	--	--	--	--
199-K-107A	P	--	--	10/18/09	13	12/3/10	14	--	-7.7
199-K-108A	P	11/18/08	-2 (U)	10/22/09	-11 (U)	--	--	--	--
199-K-31	M	--	--	10/22/09	-2.4 (U)	12/8/10	-0.87 (U)	--	NC
199-K-132	E	--	--	10/20/09	-3.2 (U)	11/22/10	-6 (U)	--	NC
199-K-137	E	10/28/08	-0.686 (U)	10/20/09	-1.8 (U)	--	--	--	--
199-K-138	E	10/28/08	-0.602 (U)	10/20/09	-0.36 (U)	11/22/10	-9.2 (U)	NC	NC
199-K-139	E	10/30/08	0.717 (U)	11/10/09	5.3	--	--	--	--
199-K-140	M	10/28/08	0.478	10/20/09	-1(U)	--	--	--	--
199-K-165	E	11/10/08	-1.89 (U)	10/20/09	-1.6 (U)	--	--	--	--
199-K-166	E	11/10/08	-1.41 (U)	10/20/09	-0.31 (U)	11/22/10	-8.8 (U)	NC	NC
199-K-167	Aband.	--	--	--	--	--	--	--	--
199-K-168	E	11/10/08	-1.87 (U)	10/20/09	-1.4 (U)	--	--	--	--
199-K-173	P	12/1/08	0.78 (U)	10/21/09	-6 (U)	--	--	--	--
199-K-174	I	--	--	--	--	--	--	--	--
199-K-175	I	--	--	--	--	--	--	--	--
AT-K-1-D/M	AT	--	--	--	--	--	--	--	--

**Table 3-8. Strontium-90 Activity in KW Reactor Area Wells and Aquifer Tubes, 2008 to 2010**

Well Name	Use	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		% Change in Sr-90 Concentration (Negative = Increase)	
		Date Collected	Sr-90 (pCi/L)	Date Collected	Sr-90 (pCi/L)	Date Collected	Sr-90 (pCi/L)	2008 to 2010	2009 to 2010

Notes:

1. Well use: C = compliance, E = extraction, I = injection, M = monitoring, P = performance
2. Abbreviations: AT = aquifer tube, NA = not available, NC = not calculated.
3. Aquifer tube nomenclature regarding relative depth: D = deepest, M = middle, S = shallowest.
4. Laboratory qualifiers: U = not detected in sample above detection limit.
5. Change in strontium-90 concentration at site AT-K-1 included sample results from both the middle and deep tube in cluster because all tubes not sampled each year.
6. Change in strontium-90 concentration not calculated (NC) when both values are nondetect (U); when and the other value is unqualified, the change is shown as increase (inc.) or decrease (dec.).
7. Blank cells (marked with "--") indicate that the sample was not collected or the analysis was not performed.

Table 3-9. Strontium-90 in KE Reactor Area Wells and Aquifer Tubes, 2008 to 2010

Well Name	Use	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		% Change in Sr-90 Conc. (Negative = Increase)	
		Date Collected	Sr-90 (pCi/L)	Date Collected	Sr-90 (pCi/L)	Date Collected	Sr-90 (pCi/L)	2008 to 2010	2009 to 2010
199-K-32A	P	--	--	10/22/09	16	12/3/10	4.4	--	72.5
199-K-32B	M (see note 1)	--	--	10/18/09	2.3	--	--	--	--
199-K-30	M	--	--	10/18/09	-2.8 (U)	12/2/10	-2.8 (U)	--	NC
199-K-29	M	--	--	--	--	12/2/10	-5 (U)	--	
199-K-27	Decom.	--	--	--	--	--	--	--	--
199-K-23	M	10/27/08	0.406 (U)	--	--	--	--	--	--
199-K-11	M	--	--	10/28/09	-0.76 (U)	--	--	--	--
199-K-109A	M	--	--	3/19/08	1120	--	--	--	--
199-K-110A	M	--	--	10/18/09	-4.6 (U)	--	--	--	--
199-K-111A	P	--	--	12/22/09	-3.2 (U)	12/7/10	1.5	--	Inc.
199-K-36	M	--	--	10/22/09	-0.81 (U)	12/3/10	-14 (U)	--	NC
199-K-141	E-KR4	10/28/08	-0.498 (U)	--	--	--	--	--	
199-K-142	P	10/28/08	-1.42 (U)	10/22/09	-3.4 (U)	9/21/10	-4.2 (U)	NC	NC
199-K-178	E-KR4	--	--	10/8/09	3.2	11/17/10	2.66	--	--
199-K-181	C	--	--	11/5/09	-11 (U)	--	--	--	--
C6241	AT	--	--	--	--	--	--	--	--
C6244	AT	--	--	11/18/09	2.3 (U)	--	--	--	--
18-S	AT	--	--	--	--	--	--	--	--
19-D	AT	--	--	11/17/09	-1 (U)	--	--	--	--

**Table 3-9. Strontium-90 in KE Reactor Area Wells and Aquifer Tubes, 2008 to 2010**

Well Name	Use	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		% Change in Sr-90 Conc. (Negative = Increase)	
		Date Collected	Sr-90 (pCi/L)	Date Collected	Sr-90 (pCi/L)	Date Collected	Sr-90 (pCi/L)	2008 to 2010	2009 to 2010
AT-K-2-M	AT	--	--	--	--	--	--	--	--

Notes:

1. Well 199-K-32B is screened within the RUM and well 199-K-32A is screened within Ringold unit E.
2. Well and aquifer tube use: M = monitoring, P = performance, E = extraction, AT = aquifer tube.
3. Abbreviations: NA = not available, NC = not calculated, NS = not sampled.
4. Aquifer tube nomenclature regarding relative depth: D = deepest, M = middle, S = shallowest.
5. Laboratory qualifiers: J = reported value is an estimate; U = not detected in sample above detection limit.
6. Change in strontium-90 concentration is not calculated (NC) when both values have "U" qualifier. When one value is undetected (U) and the second value is unqualified, the change is noted as an increase (inc.) or decrease (dec.).
7. Blank cells (marked with "--") indicate that the sample was not collected or the analysis was not performed.

Table 3-10. Carbon-14 Activity in 116-K-2 Trench and K North Wells and Aquifer Tubes, 2008 to 2010

Well or Aquifer Tube Name	Use	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		% Change in C-14 Conc.	
		Date Collected	C-14 (pCi/L)	Date Collected	C-14 (pCi/L)	Date Collected	C-14 (pCi/L)	2008 to 2010	2009 to 2010
199-K-18	C	10/23/08	26.5	10/22/09	30.2	12/8/10	21.5	18.9	28.8
199-K-19	P	--	--	10/18/09	5.34 (U)	12/3/10	8.76	--	Inc.
199-K-20	C	10/29/08	4.73 (U)	10/28/09	6.05 (U)	--	--	--	--
199-K-21	P	--	--	10/18/09	6.92 (U)	12/3/10	7.31 (U)	--	NC
199-K-22	P	--	--	10/22/09	4.49 (U)	--	--	--	
199-K-37	P	--	--	10/22/09	7.16 (U)	12/3/10	4.44 (U)	--	NC
199-K-113A	E/C-KR4	--	--	10/21/09	4.56 (U)	--	--	--	--
199-K-114A	E/C-KR4	--	--	10/21/09	5.79 (U)	--	--	--	--
199-K-115A	E/C-KR4	--	--	10/21/09	1.68 (U)	--	--	--	--
199-K-116A	E/C-KR4	--	--	10/21/09	5.36 (U)	--	--	--	--
199-K-117A	C	--	--	10/22/09	2.66 (U)	12/3/10	3.43 (U)	--	NC
199-K-129	E/C-KR4	--	--	10/21/09	1.33 (U)	--	--	--	--
199-K-130	E/C-KX	11/19/08	29.5 (U)	10/20/09	8.49	11/22/10	9.87 (U)	NC	Dec.
199-K-131	E/C-KX	--	--	10/20/09	4.02 (U)	--	--	--	--
199-K-143	I-KR4	--	--	--	--	--	--	--	--
199-K-144	E/C-KR4	--	--	--	--	--	--	--	--
199-K-145	E/C-KR4	--	--	--	--	--	--	--	--
199-K-146	E/C-KX	--	--	10/20/09	1.94 (U)	--	--	--	--
199-K-147	E/C-KX	--	--	10/20/09	4.37 (U)	11/22/10	6.39 (U)	--	NC
199-K-148	E/C-KX	--	--	10/20/09	9.32 (U)	11/22/10	5.28 (U)	--	NC

Table 3-10. Carbon-14 Activity in 116-K-2 Trench and K North Wells and Aquifer Tubes, 2008 to 2010

Well or Aquifer Tube Name	Use	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		% Change in C-14 Conc.	
		Date Collected	C-14 (pCi/L)	Date Collected	C-14 (pCi/L)	Date Collected	C-14 (pCi/L)	2008 to 2010	2009 to 2010
199-K-149	E/C-KX	--	--	10/20/09	8.37 (U)	--	--	--	--
199-K-150	E/C-KX	--	--	10/20/09	18.9	--	--	--	--
199-K-151	P	9/24/08	6.04 (U)	10/22/09	6.11 (U)	--	--	--	--
199-K-152	P	9/24/08	17.1	10/22/09	7.14 (U)	--	--	--	--
199-K-153	M	9/24/08	1.85 (U)	--	--	11/22/10	9.8	Inc.	--
199-K-154	E-KX	9/24/08	4.93 (U)	--	--	11/22/10	2.84 (U)	--	--
199-K-156	I-KX	--	--	--	--	--	--	--	--
199-K-157	P	11/18/08	140	10/29/09	54.3	--	--	--	--
199-K-159	I-KX	--	--	--	--	--	--	--	--
199-K-160	I-KX	--	--	--	--	--	--	--	--
199-K-161	E/C-KX	--	--	10/21/09	2.9 (U)	11/22/10	2.33 (U)	--	NC
199-K-162	E/C-KR4	--	--	--	--	--	--	--	--
199-K-163	E/C-KX	11/9/08	6.67 (U)	--	--	11/22/10	7.39 (U)	NC	--
199-K-164	I-KX	--	--	--	--	--	--	--	--
199-K-169	I-KX	--	--	--	--	--	--	--	--
199-K-170	I-KX	--	--	--	--	--	--	--	--
199-K-171	E-KX	9/5/08	-0.805 (U)	--	--	11/22/10	5.91 (U)	NC	--
199-K-179	I-KX	--	--	11/5/09	8.05 (U)	--	--	--	--
199-N-16	P	--	--	10/18/09	4.96 (U)	--	--	--	--
199-N-71	P	11/8/08	20.7	10/21/09	21.1	--	--	--	--

Table 3-10. Carbon-14 Activity in 116-K-2 Trench and K North Wells and Aquifer Tubes, 2008 to 2010

Well or Aquifer Tube Name	Use	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		% Change in C-14 Conc.	
		Date Collected	C-14 (pCi/L)	Date Collected	C-14 (pCi/L)	Date Collected	C-14 (pCi/L)	2008 to 2010	2009 to 2010
199-N-72	P	11/18/08	19.4	--	--	--	--	--	--
699-78-62	M	--	--	--	--	--	--	--	--
C6248	AT	9/30/08	3.9 (U)	--	--	--	--	--	--
C6250	AT	9/30/08	0.971 (U)	11/17/09	0.286 (U)	--	--	--	--
C6251	AT	11/6/08	-6.79 (U)	--	--	--	--	--	--
C6253	AT	11/6/08	20.8	11/21/09	8.14 (U)	--	--	--	--
C6256	AT	11/5/08	40 (U)	11/21/09	9.46	--	--	--	--
C6259	AT	11/10/08	-7.53 (U)	11/21/09	4.61 (U)	--	--	--	--
C6260	AT	11/10/08	-29.1 (U)	--	--	--	--	--	--
18-S	AT	10/28/98	100	11/18/09	22.6	--	--	--	-77.4
19-D/M	AT	10/30/2000	2.14 (U)	11/17/09	-0.451 (U)	--	--	--	--
AT-K-3-D/M	AT	--	--	11/1/09	21.2	--	--	--	--

## Notes:

1. Well use: C = compliance, M = monitoring, P = performance, AT = aquifer tube.
2. Abbreviations: NA = not available, NC = not calculated, NS = not sampled.
3. Aquifer tube nomenclature indicates relative depth: D = deepest, M = middle, S = shallowest.
4. Laboratory qualifiers: J = reported value is an estimate, U = not detected in sample above detection limit.
5. Change in carbon-14 concentration at some aquifer tube clusters may include sample results from both the middle and deep tube in cluster because all tubes not sampled each year.
6. Change in carbon-14 concentration not calculated when both results include "U" (nondetect) qualifiers. When one compared result included a "U" qualifier and the second result is unqualified, the change in concentration is shown as increase (inc.) or decrease (dec.).
7. Blank cells (marked with "--") indicate that the sample was not collected or the analysis was not performed.

Table 3-11. Carbon-14 Activities at KW Reactor Area Wells and Aquifer Tubes, 2000 to 2010

Well Name	Well Use or Aquifer Tube	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		% Change in C-14 Conc. (Negative = Increase)	
		Date Collected	C-14 (pCi/L)	Date Collected	C-14 (pCi/L)	Date Collected	C-14 (pCi/L)	2008 to 2010	2009 to 2010
199-K-34	M	10/27/08	4,680	10/22/09	1,910	12/7/10	2,590	44.7	-34.9
199-K-35	M	--	--	--	--	--	--	--	--
199-K-106A	M	10/6/08	2,860	10/22/09	3,970	--	--	--	--
199-K-107A	M	10/6/08	302	10/18/09	282	--	--	--	--
199-K-108A	M	10/6/08	2,210	10/22/09	946	--	--	--	--
199-K-31	M	10/27/08	240	10/22/09	565	12/8/10	396	-65.0	29.9
199-K-132	E	10/28/08	2,630	10/20/09	2,320	11/22/10	2,350	10.6	-1.3
199-K-137	M	10/28/08	1,830	10/20/09	950	--	--	--	--
199-K-138	E	10/28/08	192 (J)	10/20/09	285	11/22/10	396	-106.3	-38.9
199-K-139	E	10/30/08	387	11/10/09	347	--	--	--	--
199-K-140	E	10/28/08	878	10/20/09	514	--	--	--	--
199-K-158	M	--	--	--	--	--	--	--	--
199-K-165	E	11/10/08	330	10/20/09	154	--	--	--	--
199-K-166	E	11/10/08	506	10/20/09	290	11/22/10	399	21.1	-37.6
199-K-168	E	10/29/08	643	10/20/09	290	--	--	--	--
199-K-173	P	12/1/08	215	10/21/09	582	--	--	--	--
199-K-174	I	--	--	--	--	--	--	--	--
199-K-175	I	--	--	--	--	--	--	--	--
AT-K-1-D	AT	--	--	11/1/09	35.2	--	--	--	--

**Table 3-11. Carbon-14 Activities at KW Reactor Area Wells and Aquifer Tubes, 2000 to 2010**

Well Name	Well Use or Aquifer Tube	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		% Change in C-14 Conc. (Negative = Increase)	
		Date Collected	C-14 (pCi/L)	Date Collected	C-14 (pCi/L)	Date Collected	C-14 (pCi/L)	2008 to 2010	2009 to 2010

Notes:

1. Well use: E = extraction, M = monitoring, P = performance, AT = aquifer tube.
2. Abbreviations: NA = not available, NC = not calculated, NS = not sampled.
3. Aquifer tube nomenclature regarding relative depth: D = deepest, M = middle, S = shallowest.
4. Laboratory qualifiers: J = value reported is an estimate.
5. Blank cells (marked with "--") indicate that the sample was not collected or the analysis was not performed.

Table 3-12. Carbon-14 Activities at KE Reactor Area Wells and Aquifer Tubes, 2008 to 2010

Well Name	Use	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		% Change in C-14 Conc. (Negative = Increase)	
		Date Collected	C-14 (pCi/L)	Date Collected	C-14 (pCi/L)	Date Collected	C-14 (pCi/L)	2008-2010	2009-2010
199-K-32A	P	10/27/08	205	10/22/09	166	12/3/10	192	6.3	-15.7
199-K-32B	M (see note 1)	--	--	10/18/09	1.01 (U)	12/8/10	3.43 (U)	--	NC
199-K-30	M	10/27/08	6130	10/18/09	5830	12/2/10	4110	33.0	29.5
199-K-29	M	--	--	--	--	12/2/10	3120	--	--
199-K-23	M	--	--	--	--	--	--	--	--
199-K-11	M	10/6/08	106	10/28/09	108	12/3/10	131	-23.6	-21.3
199-K-110A	M	--	--	10/18/09	152	--	--	--	--
199-K-111A	P	10/21/09	252	10/21/09	208	--	--	--	--
199-K-36	M	--	--	10/22/09	91	12/3/10	65.1	--	28.5
199-K-141	E-KR4	10/28/08	84.4	--	--	--	--	--	--
199-K-142	P	10/28/08	291	10/22/09	209	12/8/10	242	16.8	-15.8
199-K-178	E-KR4	--	--	10/8/09	200	11/17/10	226	--	-13.0
199-K-181	P	--	--	10/8/09	270	--	--	--	--
C6241	AT	--	--	11/15/09	158	--	--	--	--
C6244	AT	--	--	11/18/09	126	--	--	--	--
C6247	AT	--	--	11/16/09	295	--	--	--	--
18-S	AT	--	--	11/18/09	22.6	--	--	--	--
19-D	AT	--	--	11/17/09	-0.451 (U)	--	--	--	--
AT-K-2-M	AT	--	--	11/1/09	188	--	--	--	--

**Table 3-12. Carbon-14 Activities at KE Reactor Area Wells and Aquifer Tubes, 2008 to 2010**

Well Name	Use	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		% Change in C-14 Conc. (Negative = Increase)	
		Date Collected	C-14 (pCi/L)	Date Collected	C-14 (pCi/L)	Date Collected	C-14 (pCi/L)	2008-2010	2009-2010

Notes:

1. Well 199-K-32B is screened within the RUM and well 199-K-32A is screened within Ringold unit E.
2. Well and aquifer tube use: M = monitoring, P = performance, AT = aquifer tube.
3. Abbreviations: NA = not available, NC = no change in concentration, NS = not sampled.
4. Aquifer tube nomenclature regarding relative depth: D = deepest, M = middle, S = shallowest.
5. Laboratory qualifiers: J = value reported is an estimate, U = not detected in sample above detection limit.
6. Change in carbon-14 concentration not calculated (NC) when both results include "U" (nondetect) qualifier. When one compared result includes "U" qualifier, and the second result is qualified, the change in concentration is shown as increase (inc.) or decrease (dec.).
7. Blank cells (marked with "--") indicate that the sample was not collected or the analysis was not performed.

Table 3-13. Nitrate Concentrations in 116-K-2 Trench and K North Area Wells and Aquifer Tubes, 2008 to 2010

Well or Aquifer Tube Name	Use	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		Change in Nitrate Conc.	
		Date Collected	Nitrate (µg/L)	Date Collected	Nitrate (µg/L)	Date Collected	Nitrate (µg/L)	2008 to 2010	2009 to 2010
199-K-18	C	10/23/08	66,000	10/22/09	73,000	12/8/10	60,600	8.1--	17.0--
199-K-19	P	10/23/08	38,600	10/18/09	30,367.8	12/3/10	26,700	30.8	12.1
199-K-20	C	10/27/08	15,200	10/28/09	15,006.9	--	--	--	--
199-K-21	P	10/23/08	17,700	10/18/09	10,757.1	12/3/10	14,800	16.4	-37.6
199-K-22	P	10/23/08	16,500	10/22/09	21,425.7	--	--	--	--
199-K-37	P	10/27/08	10,200	10/22/09	10,403	12/3/10	6,770	33.6	34.9
199-K-113A	E/C-KR4	--	--	10/21/09	9,384.82	--	--	--	--
199-K-114A	E/C-KR4	--	--	10/21/09	9,207.74	--	--	--	--
199-K-115A	E/C-KR4	--	--	10/21/09	11,000	--	--	--	--
199-K-116A	E/C-KR4	--	--	10/21/09	15,892.2	--	--	--	--
199-K-117A	C	10/6/08	6,020	10/22/09	4,360.4	12/3/10	1,920	68.1	56.0
199-K-129	E/C-KR4	--	--	10/21/09	8,810	--	--	--	--
199-K-130	E/C-KX	--	--	10/20/09	11,908.1	11/22/10	11,900	--	0.1
199-K-131	E/C-KX	--	--	10/20/09	13,400	--	--	--	--
199-K-143	I-KR4	--	--	--	--	--	--	--	--
199-K-144	E/C-KR4	--	--	--	--	--	--	--	--
199-K-145	E/C-KR4	--	--	--	--	--	--	--	--
199-K-146	E/C-KX	--	--	10/20/09	8,630	--	--	--	--
199-K-147	E/C-KX	--	--	10/20/09	10,580.1	11/22/10	11,400	--	-7.7
199-K-148	E/C-KX	--	--	10/20/09	14,608.4	11/22/10	13,800	--	5.5

Table 3-13. Nitrate Concentrations in 116-K-2 Trench and K North Area Wells and Aquifer Tubes, 2008 to 2010

Well or Aquifer Tube Name	Use	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		Change in Nitrate Conc.	
		Date Collected	Nitrate (µg/L)	Date Collected	Nitrate (µg/L)	Date Collected	Nitrate (µg/L)	2008 to 2010	2009 to 2010
199-K-149	E/C-KX	--	--	10/20/09	22,300	--	--	--	--
199-K-150	E/C-KX	--	--	10/20/09	16,202.1	--	--	--	--
199-K-151	P	--	--	10/22/09	9,606.16	9/20/10	6,600	--	31.3
199-K-152	P	--	--	10/22/09	8,455.19	9/21/10	7,610	--	10.0
199-K-153	M	--	--	--	--	11/22/10	10,400	--	--
199-K-154	E-KX	--	--	--	--	11/22/10	10,400	--	--
199-K-156	I-KX	--	--	--	--	--	--	--	--
199-K-157	P	--	--	10/29/09	41,921.8	12/7/10	22,300	--	46.8
199-K-159	I-KX	--	--	--	--	--	--	--	--
199-K-160	I-KX	--	--	--	--	--	--	--	--
199-K-161	E/C-KX	--	--	10/21/09	12,572.1	11/22/10	2,640	--	79.0
199-K-162	E/C-KR4	--	--	--	--	--	--	--	--
199-K-163	E/C-KX	--	--	--	--	11/22/10	14,300	--	--
199-K-164	I-KX	--	--	--	--	--	--	--	--
199-K-169	I-KX	--	--	--	--	--	--	--	--
199-K-170	I-KX	--	--	--	--	--	--	--	--
199-K-171	E-KX	--	--	--	--	11/22/10	14,200	--	--
199-K-179	I-KX	--	--	11/5/09	12,306.5	--	--	--	--
199-N-16	P	--	--	10/18/09	--	--	--	--	--
199-N-71	P	11/8/08	--	10/21/09	--	--	--	--	--

Table 3-13. Nitrate Concentrations in 116-K-2 Trench and K North Area Wells and Aquifer Tubes, 2008 to 2010

Well or Aquifer Tube Name	Use	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		Change in Nitrate Conc.	
		Date Collected	Nitrate (µg/L)	Date Collected	Nitrate (µg/L)	Date Collected	Nitrate (µg/L)	2008 to 2010	2009 to 2010
199-N-72	P	11/18/08	--	--	--	--	--	--	--
699-78-62	M	--	--	--	--	--	--	--	--
C6248	AT	9/30/08	--	--	--	--	--	--	--
C6250	AT	9/30/08	--	11/17/09	--	--	--	--	--
C6251	AT	11/6/08	--	--	--	--	--	--	--
C6253	AT	11/6/08	--	11/21/09	--	--	--	--	--
C6256	AT	11/5/08	--	11/21/09	--	--	--	--	--
C6259	AT	11/10/08	--	11/21/09	--	--	--	--	--
C6260	AT	11/10/08	--	--	--	--	--	--	--
18-S	AT	10/28/98	--	11/18/09	--	--	--	--	--
19-D/M	AT	10/30/00	--	11/17/09	--	--	--	--	--
AT-K-3-D/M	AT	--	--	11/1/09	--	--	--	--	--

## Notes:

1. Well use: C = compliance, M = monitoring, P = performance, AT = aquifer tube.
2. Abbreviations: NA = not available, NC = not calculated, NS = not sampled.
3. Aquifer tube nomenclature indicates relative depth: D = deepest, M = middle, S = shallowest.
4. Laboratory qualifiers: J = reported value is an estimate, U = not detected in sample above detection limit.
5. Change in nitrate concentration at some aquifer tube clusters may include sample results from both the middle and deep tube in cluster because all tubes not sampled each year.
6. Blank cells (marked with "--") indicate that the sample was not collected or the analysis was not performed.

Table 3-14. Nitrate Concentrations at KW Reactor Area Wells and Aquifer Tube, 2008 to 2010

Well Name	Well Use or Aquifer Tube	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		% Change in Nitrate Conc. (Negative = Increase)	
		Date Collected	Nitrate (µg/L)	Date Collected	Nitrate (µg/L)	Date Collected	Nitrate (µg/L)	2008 to 2010	2009 to 2010
199-K-34	M	10/27/08	53,100	10/22/09	53,100	12/7/10	32,600	38.6	38.6
199-K-35	M	--	--	12/22/09	31,961.5	--	--	--	--
199-K-106A	M	10/6/08	89,900	10/22/09	96,061.6	9/13/10	73,900	17.8	23.1
199-K-107A	M	10/6/08	22,200	10/18/09	22,089.7	12/3/10	23,200	-4.5	-5.0
199-K-108A	M	10/6/08	69,100	10/22/09	61,500	--	--	--	--
199-K-31	M	10/27/08	24,000	10/22/09	24,126.1	12/8/10	24,600	-2.5	-2.0
199-K-132	E	10/28/08	28,300	10/20/09	31,695.9	11/22/10	34,300	-21.2	-8.2
199-K-137	M	10/28/08	16,500	10/20/09	26,428	--	--	--	--
199-K-138	E	10/28/08	21,381.4	10/20/09	--	11/22/10	22,100	-3.4	--
199-K-139	E	10/30/08	--	11/10/09	24,834.3	--	--	--	--
199-K-140	E	10/28/08	--	10/20/09	21,200	--	--	--	--
199-K-158	M	--	--	--	--	--	--	--	--
199-K-165	E	9/11/08	17,400	10/20/09	17,264.5	--	--	--	--
199-K-166	E	9/25/08	193,000	10/20/09	20,009.1	11/22/10	22,400	88.4	-11.9
199-K-168	E	--	--	10/20/09	18,902.4	--	--	--	--
199-K-173	P	9/27/08	17,400	10/21/09	19,079.5	--	--	--	--
199-K-174	I	--	--	--	--	--	--	--	--
199-K-175	I	--	--	--	--	--	--	--	--
AT-K-1-D	AT	--	--	11/1/09	--	--	--	--	--

**Table 3-14. Nitrate Concentrations at KW Reactor Area Wells and Aquifer Tube, 2008 to 2010**

Well Name	Well Use or Aquifer Tube	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		% Change in Nitrate Conc. (Negative = Increase)	
		Date Collected	Nitrate (µg/L)	Date Collected	Nitrate (µg/L)	Date Collected	Nitrate (µg/L)	2008 to 2010	2009 to 2010

Notes:

1. Well use: E = extraction, M = monitoring, P = performance, AT = aquifer tube.
2. Abbreviations: NA = not available, NC = not calculated, NS = not sampled.
3. Aquifer tube nomenclature regarding relative depth: D = deepest, M = middle, S = shallowest.
4. Laboratory qualifiers: J = value reported is an estimate.
5. Blank cells (marked with "--") indicate that the sample was not collected or the analysis was not performed.

Table 3-15. Nitrate Concentrations at KE Reactor Area Wells and Aquifer Tubes, 2008 to 2010

Well Name	Well Use or Aquifer Tube	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		% Change in Nitrate Conc. (Negative = Increase)	
		Date Collected	Nitrate (µg/L)	Date Collected	Nitrate (µg/L)	Date Collected	Nitrate (µg/L)	2008-2010	2009-2010
199-K-32A	P	10/27/08	20,900	10/22/09	20,717.4	12/3/10	19,000	9.1	8.3
199-K-32B	M (see note 1)	10/27/08	10,400	10/18/09	10,270.2	--	--	--	--
199-K-30	M	10/27/08	79,700	10/18/09	31,076.1	12/2/10	25,100	68.5	19.2
199-K-29	M	--	--	--	--	12/2/10	46,500	--	--
199-K-23	M	10/27/08	63,700	--	--	--	--	--	--
199-K-11	M	10/6/08	69,100	10/28/09	49,100	12/3/10	39,700	42.5	19.1
199-K-110A	M	10/6/08	9,960	10/18/09	13,200	12/8/10	10,800	-8.4	18.2
199-K-111A	P	10/6/08	42,900	10/21/09	43,400	12/7/10	37,100	13.5	14.5
199-K-36	M	10/27/08	22,100	10/22/09	23,500	12/3/10	28,100	-27.1	-19.6
199-K-141	E-KR4	10/28/08	30,000	--	--	--	--	--	--
199-K-142	P	10/28/08	3,130	10/22/09	2,253.24	12/8/10	1,420	54.6	37.0
199-K-178	E-KR4	--	--	10/8/09	16,998.9	11/17/10	13,900	--	--
199-K-181	P	--	--	10/8/09	17,600	--	--	--	--
C6241	AT	--	--	--	--	--	--	--	--
C6244	AT	--	--	--	--	--	--	--	--
C6247	AT	--	--	--	--	--	--	--	--
18-S	AT	--	--	--	--	--	--	--	--
19-D	AT	--	--	--	--	--	--	--	--
AT-K-2-M	AT	--	--	--	--	--	--	--	--

**Table 3-15. Nitrate Concentrations at KE Reactor Area Wells and Aquifer Tubes, 2008 to 2010**

Well Name	Well Use or Aquifer Tube	Fall 2008		Fall 2009 Sample		Fall 2010 Sample		% Change in Nitrate Conc. (Negative = Increase)	
		Date Collected	Nitrate (µg/L)	Date Collected	Nitrate (µg/L)	Date Collected	Nitrate (µg/L)	2008-2010	2009-2010

Notes:

1. Well 199-K-32B is screened within the RUM and well 199-K-32A is screened within Ringold unit E.
2. Well and aquifer tube use: M = monitoring, P = performance, AT = aquifer tube.
3. Abbreviations: NA = not available, NC = no change in concentration, NS = not sampled.
4. Aquifer tube nomenclature regarding relative depth: D = deepest, M = middle, S = shallowest.
5. Laboratory qualifiers: J = value reported is an estimate, U = not detected in sample above detection limit.
6. Blank cells (marked with "--") indicate that the sample was not collected or the analysis was not performed.

Table 3-16. TCE Concentrations in KE Reactor Area Wells and Aquifer Tubes, 2008 to 2010

Well Name	Use	Fall 2008 Unfiltered TCE		Fall 2009 Unfiltered TCE		Fall 2010* Unfiltered TCE		% Change in TCE Conc. (Negative = Increase)	
		Date Collected	Conc. (µg/L)	Date Collected	Conc. (µg/L)	Date Collected	Conc. (µg/L)	2008-2010	2009-2010
199-K-106A	M	10/6/08	3.5(J)	10/22/09	2.8(J)	--	--	--	--
199-K-107A	M	--	--	--	--	12/3/10	3.5(J)	--	--
199-K-108A	M	--	--	10/22/08	4.1(J)	--	--	--	--
199-K-11	--	--	--	10/28/09	1.6(J)	--	--	--	--
199-K-117A	C	--	--	10/22/09	1(U)	--	--	--	--
199-K-132	E	10/28/08	4.23(J)	10/20/09	6.2	11/22/10	5.4	-1.17	0.8
199-K-138	E	10/28/08	2.66(J)	--	--	11/22/10	4.1(J)	-1.44	--
199-K-139	E	10/30/09	3.13(J)	--	--	--	--	--	--
199-K-140	M	10/28/08	4.7	--	--	--	--	--	--
199-K-142	--	--	--	10/22/09	1(U)	--	--	--	--
199-K-151	p	--	--	10/22/09	1(U)	9/20/10	0.25	--	--
199-K-152	p	--	--	10/22/09	1(U)	9/21/10	0.25	--	--
199-K-157	p	--	--	10/29/09	1(U)	--	--	--	--
199-K-165	E	11/10/08	4.24(J)	--	--	--	--	--	--
199-K-166	E	11/10/08	2.77(J)	--	--	11/22/10	3.7(J)	-0.93	--
199-K-168	E	11/10/08	3.65(J)	--	--	--	--	--	--
199-K-173	M	12/1/08	2.6(J)	10/21/09	3.8(J)	9/21/10	4.2(J)	-1.6	-0.4
199-K-18	C	--	--	10/22/09	1(U)	--	--	--	--
199-K-182	--	--	--	--	--	9/20/10	0.25(U)	--	--

Table 3-16. TCE Concentrations in KE Reactor Area Wells and Aquifer Tubes, 2008 to 2010

Well Name	Use	Fall 2008 Unfiltered TCE		Fall 2009 Unfiltered TCE		Fall 2010* Unfiltered TCE		% Change in TCE Conc. (Negative = Increase)	
		Date Collected	Conc. (µg/L)	Date Collected	Conc. (µg/L)	Date Collected	Conc. (µg/L)	2008-2010	2009-2010
199-K-189	--	--	--	--	--	9/2/10	1(U)	--	--
199-K-20	C	--	--	10/28/09	1(U)	--	--	--	--
199-K-201	--	--	--	--	--	9/15/10	1(U)	--	--
199-K-22	P	--	--	10/22/08	1(U)	--	--	--	--
199-K-31	M	--	--	10/22/09	3.1(J)	--	--	--	--
199-K-32A	P	--	--	10/22/09	1(U)	--	--	--	--
199-K-34	--	--	--	10/22/09	1(U)	--	--	--	--
199-K-36	--	--	--	10/22/09	1(U)	--	--	--	--
199-K-37	P	--	--	10/22/09	1(U)	9/20/10	0.25(U)	--	--
699-73-61	--	--	--	--	--	9/19/10	0.46(J)	--	--
C7641	--	--	--	--	--	11/22/10	1(U)	--	--
C7642	--	--	--	--	--	11/22/10	1(U)	--	--
C7643	--	--	--	--	--	11/22/10	1(U)	--	--

Table 3-16. TCE Concentrations in KE Reactor Area Wells and Aquifer Tubes, 2008 to 2010

Well Name	Use	Fall 2008 Unfiltered TCE		Fall 2009 Unfiltered TCE		Fall 2010* Unfiltered TCE		% Change in TCE Conc. (Negative = Increase)	
		Date Collected	Conc. (µg/L)	Date Collected	Conc. (µg/L)	Date Collected	Conc. (µg/L)	2008-2010	2009-2010

Notes:

1. Laboratory qualifiers: B = detected above instrument or method detection limit, but below contract-required detection limit, D = sample diluted; C = analyte detected in both the sample and the associated quality control blank, and the sample concentration was less than or equal to five times the blank concentration; U = analyte undetected and the detection limit is included within parentheses; J = estimated value (a) constituent detected at a level less than the required detection limit or practical quantitation limit and greater than or equal to the MDL, (2) estimated concentration for tentatively identified compounds.

2. Well use: C = compliance, E = extraction, I = injection, M = monitoring, P = performance.

3. Abbreviations: NA = not available, NC = not calculated, UF = unfiltered, AT = aquifer tube.

4. Blank cells (marked with "--") indicate that the sample was not collected, the analysis was not performed or the change in concentration was not calculated.

5. Where contaminant concentration comparisons involve one nonqualified result and one nondetect (U) result, the percent change was not calculated but rather an increase (inc.) or decrease (dec.) in concentration between years was noted.

\* Fall 2010 data includes September 2010 due to limited sampling in the period of October through December 2010.

**Table 3-17. Operational Parameters and System Performance of KR4 P&T System**

<b>Total Processed Groundwater</b>	<b>CY 2009</b>	<b>CY 2010</b>
Total amount of groundwater treated (since October 1997 startup) (billion L)	5.31	5.65
Total amount of groundwater treated during CY (million L)	317.5	336.9
<b>Mass of Hexavalent Chromium Removed</b>		
Total amount of hexavalent chromium removed since October 1997 startup (kg)	347.5	354.7
Total amount of hexavalent chromium removed in CY (kg)	14.98	7.21
<b>Summary of Operational Parameters</b>		
Removal efficiency (% by mass)	86.9%	90.6%
Waste generation (m <sup>3</sup> )	0	0
Regenerated resin installed (m <sup>3</sup> )	29.4	45
New resin installed (m <sup>3</sup> )	0	0
Number of resin vessel changeouts	--	20
<b>Summary of System Availability</b>		
Total possible run-time (hours)	8,760	8,760
Scheduled downtime (hours)	53.6	2,170
Planned operations (hours)	8,706.4	6,590
Unscheduled downtime (hours)	1,089.8	22.1
Total time online (hours)	7,616.6	6,567.9
Total availability (%)	86.9%	74.9%
Scheduled system availability (%)	99.4%	75.2%*

\* The relatively low system availability in CY 2010 is due to a system shutdown for upgrades and maintenance during the last 3 months of the year.

**Table 3-18. Flow Rates and Total Run-Times for KR4 System  
Extraction and Injection Wells, CY 2010**

<b>Well</b>	<b>Recommended<sup>a</sup> Flow Rate, L/min (gpm)</b>	<b>Yearly Avg Flow Rate, L/min (gpm)</b>	<b>Total Flow Hours in CY 2010</b>	<b>Percent Total Run-Time<sup>b</sup></b>	<b>Purpose</b>
199-K-129	94.6 (25.0)	29.5 (7.8)	5,257.4	78.8%	Extraction
199-K-113A	56.8 (15.0)	32.6 (8.6)	3,867	58.0%	Extraction
199-K-114A	94.6 (25.0)	55.3 (14.6)	4,996.4	74.9%	Extraction
199-K-115A	94.6 (25.0)	80.3 (21.2)	5,992.6	89.8%	Extraction
199-K-116A	151.4 (40.0)	163.2 (43.1)	5,911	88.6%	Extraction
199-K-120A	113.6 (30.0)	129.1 (34.1)	4,910.8	73.6%	Extraction
199-K-127	151.4 (40.0)	139.7 (36.9)	2,214.9	33.2%	Extraction
199-K-144 <sup>c</sup>	TBD	129.5 (34.2)	2,053.5	30.8%	Extraction
199-K-145 <sup>c</sup>	TBD	170.0 (44.9)	2,696.3	40.4%	Extraction
199-K-162 <sup>c</sup>	TBD	148.8 (39.3)	2,355.4	35.3%	Extraction
199-K-121A	NA	120.8 (31.9)	1,916.9	28.7%	Injection
199-K-122A	NA	197.6 (52.2)	3,133.3	47.0%	Injection
199-K-123A	NA	93.5 (24.7)	1,483.4	22.2%	Injection
199-K-128	NA	191.2 (50.5)	3,027	45.4%	Injection
199-K-179	NA	277.8 (73.4)	4,406.8	66.0%	Injection

a. Recommended flow rate based upon drawdown analysis.

b. Total flow hours in CY 2010 ÷ total hours in CY 2010 (hours until shutdown of plant on October 5) x 100%.

c. Put into service in February 2010.

**Table 3-19. Operational Parameters and System Performance for KW P&T System**

<b>Total Processed Groundwater</b>	<b>CY 2009</b>	<b>CY 2010</b>
Total amount of groundwater treated since January 2007 startup (million L)	666.99	1,054.14
Total amount of groundwater treated in CY (million L)	297.63	387.15
<b>Mass of Hexavalent Chromium Removed</b>		
Total amount of hexavalent chromium removed since January 2007 startup (kg)	83.28	137.42
Total amount of hexavalent chromium removed in CY (kg)	49.25	54.14
<b>Summary of Operational Parameters</b>		
Removal efficiency (% by mass)	95.8%	96.9%
Waste generation (m <sup>3</sup> )	---	0
Regenerated resin installed (m <sup>3</sup> )	24.9	93
New resin installed (m <sup>3</sup> )	24.9	27
Number of resin vessel changeouts	--	41
<b>Summary of System Availability</b>		
Total possible run-time (hours)	8,760	8,760
Scheduled downtime (hours) <sup>a</sup>	268.8	29.3
Planned operations (hours)	8,491.2	8,730.7
Unscheduled downtime (hours)	118.0	6.2
Total time online (hours)	8,372.2	8,724.5
Total availability (%)	95.6%	99.6%
Scheduled system availability (%) <sup>b</sup>	98.6%	99.7%

a. Scheduled system availability [(total possible run-time – scheduled downtime) ÷ total possible run-time].

b. Total availability [(total possible run-time – scheduled and unscheduled downtime) ÷ total possible run-time].

**Table 3-20. Flow Rates and Total Run-Time for KW P&T System  
Extraction/Injection Wells, CY 2010**

<b>Well</b>	<b>Recommended<sup>a</sup> Flow Rate, L/min (gpm)</b>	<b>Yearly Avg. Flow Rate, L/min (gpm)</b>	<b>Total Flow Hours in CY 2010</b>	<b>Percent Total Run-Time<sup>b</sup></b>	<b>Purpose</b>
199-K-132	96 (25)	46.0 (12.2)	8,347.6	95.3%	Extraction
199-K-137	170 (45)	118.0 (31.2)	8,377	95.6%	Extraction
199-K-138	114 (30)	70.0 (18.5)	8,649.9	98.7%	Extraction
199-K-139 <sup>c</sup>	38 (10)	109.7 (29.0)	6,326.5	72.2%	Extraction
199-K-165	189 (50)	204.8 (54.1)	8,330	95.1%	Extraction
199-K-166	38 (10)	81.3 (21.5)	8,484.1	96.9%	Extraction
199-K-168	151 (40)	159.6 (42.2)	8,569	97.8%	Extraction
199-K-158	NA	347.0 (91.7)	8,677.7	99.1%	Injection
199-K-174	NA	263.4 (69.6)	8,666.7	98.9%	Injection
199-K-175	NA	132.1 (34.9)	8,661.2	98.9%	Injection

a. Recommended flow rate based upon drawdown analysis.

b. Percentage total run-time calculated by (total flow hours ÷ total possible run-time).

c. Put into service in April 2010.

**Table 3-21. Operational Parameters and System Performance for KX P&T System**

<b>Total Processed Groundwater</b>	<b>CY 2009</b>	<b>CY 2010</b>
Total amount of groundwater treated since November 2008 startup (million L)	656	1,561
Total amount of groundwater treated in CY (million L)	590	904
<b>Mass of Hexavalent Chromium Removed</b>		
Total amount of hexavalent chromium removed since November 2008 startup (kg)	43.8	83.9
Total amount of hexavalent chromium removed in CY (kg)	39.9	40.13
<b>Summary of Operational Parameters</b>		
Removal efficiency (% by mass)	96.3	94.0
Waste generation (m <sup>3</sup> )	--	0
Regenerated resin installed (m <sup>3</sup> )	6.1.2	147
New resin installed (m <sup>3</sup> )	97.4	52
Number of resin vessel changeouts	--	65
<b>Summary of System Availability</b>		
Total possible run-time (hours)	7,968.0	8,760
Scheduled downtime (hours)	152.2	68.6
Planned operations (hours)	7,815.8	8,691.4
Unscheduled downtime (hours)	288.1	214.7
Total time on-line (hours)	7,527.7	8,476.7
Total availability (%) <sup>b</sup>	98.1%	96.8
Scheduled system availability (%) <sup>a</sup>	94.5	99.2

a. Scheduled system availability [(total possible run-time – scheduled downtime) ÷ total possible run-time].

b. Total availability [(total possible run-time – scheduled and unscheduled downtime) ÷ total possible run-time].

**Table 3-22. Pumping Flow Rates and Total Run-Time  
for Extraction/Injections Wells at KX P&T System**

<b>Well</b>	<b>Recommended<sup>b</sup> Flow Rate, L/min (gpm)</b>	<b>Yearly Avg. Flow Rate, L/min (gpm)</b>	<b>Total Flow Hours in CY 2010</b>	<b>Total Run-Time (%)<sup>a</sup></b>	<b>Purpose</b>
199-K-130	227 (60)	108.7 (28.7)	8,441	96.4%	Extraction
199-K-131	227 (60)	201.2 (53.2)	8,390	95.8%	Extraction
199-K-141	TBD	128.6 (34.0)	7,616	86.9%	Extraction
199-K-146	38 (10)	34.3 (9.1)	8,435	96.3%	Extraction
199-K-147	76 (20)	71.8 (19.0)	8,080	92.2%	Extraction
199-K-148	189 (50)	157.6 (41.6)	8,286	94.6%	Extraction
199-K-149c	189 (50)	164.2 (43.4)	3,735	42.6%	Extraction
199-K-150c	189 (50)	93.2 (24.6)	1,437	16.4%	Extraction
199-K-153	TBD	265.6 (70.2)	6,062.1	69.2%	Extraction
199-K-154	TBD	231.6 (61.2)	8,366	95.5%	Extraction
199-K-161	114 (30)	73.1 (19.3)	6,381	72.8%	Extraction
199-K-163	TBD	231.4 (61.1)	8,319	95.0%	Extraction
199-K-171	TBD	228.3 (60.3)	6,524	74.5%	Extraction
199-K-178d	TBD	188.2 (49.7)	6,045	69.0%	Extraction
199-K-143	NA	94.0 (24.8)	7,975.5	91.0%	Injection
199-K-156	NA	241.9 (63.9)	8,394.5	95.8%	Injection
199-K-159	NA	226.6 (59.9)	8,479.5	96.8%	Injection
199-K-160	NA	228.4 (60.4)	8,472.2	96.7%	Injection
199-K-164	NA	180.8 (47.8)	8,476.5	96.8%	Injection
199-K-169	NA	211.5 (55.9)	8,472.5	96.7%	Injection
199-K-170	NA	201.8 (53.3)	8,466.7	96.7%	Injection
199-K-172	NA	248.0 (65.5)	8,313.8	94.9%	Injection
199-K-180d	NA	198.1 (52.3)	6,619.6	75.6%	Injection

a. Percentage total run-time calculated by (total flow hours ÷ total possible run-time).

b. Recommended flow rate based upon drawdown analysis.

c. Removed from service as extraction well in June 2010.

d. Put into service in March 2010.

## 4 100-NR-2 Operable Unit Interim Action Status

The 100-NR-2 Groundwater OU is located along the Columbia River between the 100-KR-4 OU and the 100-HR-3 OU (Figure 4-1). The 100-NR-2 OU consists of the groundwater underlying and near the source OU associated with the 100-N Area. The 100-NR-2 P&T system, which began operating in September 1995, was placed in cold-standby status in March 2006. This action facilitated the installation and interpretation of a treatability test for a 91.4 m (300 ft) long apatite PRB constructed along the 100-N Area shoreline. Figure 4-2 shows the location of the former 100-NR-2 OU P&T extraction and injection wells and the associated monitoring wells in relation to the primary facilities. The figure also shows the area of the apatite PRB in relation to these wells; Figure 4-3 shows an enlargement of the inset PRB area. The authorization for the P&T status change in the 100-NR-2 interim action is documented in Tri-Party Agreement Change Request M-16-06-01, dated February 15, 2006.

This chapter provides the annual performance report for the 100-NR-2 OU groundwater remediation, as required by the interim remedial action ROD (EPA/ROD/R10-99/112). The purpose of this chapter is to report groundwater monitoring data collected in CY 2010 and to describe the observed effects of the P&T system's cold-standby status on the aquifer. A general overview of the effects of the apatite PRB is provided, as well as an update on progress for other remediation activities currently taking place in the 100-NR-2 OU.

Section 4.1 provides a brief overview of activities pertaining to the 100-NR-1 source area remedial actions and 100-NR-2 groundwater remediation activities that have occurred within the OU for CY 2010. Section 4.2 describes the basic conceptual site model, including environmental conditions and groundwater contaminants. Section 4.3 discusses the strontium-90 treatment technologies currently being tested and planned for future testing in the OU. Section 4.4 discusses activities related to the TPH-diesel plume contamination occurring in the 100-N Area. The conclusions and recommendations are presented in Sections 4.5 and 4.6, respectively.

### 4.1 Overview

The progress on source removal and groundwater remediation activities for CY 2010 is summarized in the following subsections.

#### 4.1.1 100-NR-1 Operable Unit

Three main projects are going on at the 100-NR-1 OU: (1) Reactor Interim Safe Storage; (2) Deactivation, Decontamination, Decommissioning, and Demolition; and (3) Field Remediation. The work being performed by the Reactor Interim Safe Storage Project deals predominately with size reduction and cocooning of the N Reactor building and fuel storage basin, and also the 109-N heat exchanger building. During 2010, progress was made in removing ancillary structures to the two buildings and constructing a roof over both buildings; this work continues into 2011.

The Deactivation, Decontamination, Decommissioning, and Demolition Project removed several buildings in CY 2010, including the 1310-N chemical waste storage facility (a.k.a., "golf ball"), the 1322-N waste treatment pilot plant facility, the 1322-NA effluent water pilot plant, the 1322-NB Crib effluent iodine monitoring facility, the 1322-NC Crib effluent iodine monitoring system, and the 1909-N waste disposal valve pit. Work also began on the 116-N exhaust stack foundation, the 117-N air filter building foundation, and river structure equipment removal in the 181-N (river water pump house) and 181-NE (Hanford Generating Plant river water pump house) buildings. Deactivation occurred at the following facilities: 105-NE (fission product filter trap), 1143-N (carpenter/paint shop), 186-N (alternative potable water plant), 1902-N (export water tie-in building), and 1902-N81 (fire

protection valve house). The Field Remediation Project worked to remove waste from (1) the burn pits/debris area between the 100-N and 100-D Areas (600-35); (2) the 100-N-11, 100-N-14, and 100-N-54 UPRs; (3) the 124-N-4 septic system tile field; and (4) 1301-N RCRA piping.

The TPH-diesel bioremediation technology test began in September/October 2010 and continues into CY 2011. Results of the test are promising and are presented in *UPR-100-N-17; Bioventing Pilot Plant Performance Report* (WCH-490).

#### 4.1.2 100-NR-2 Operable Unit

The activities required for the 100-NR-2 OU by the interim action ROD (EPA/ROD/R10-99/112) to address strontium-90 and other contaminants in groundwater near the source areas consist of (1) maintaining a groundwater monitoring network for tracking changes in contaminant concentrations, (2) investigating alternative treatment technologies (i.e., emplacing the apatite PRB and testing other strontium-90 remediation technologies, (3) assessing ecological risk of contaminated groundwater, and (4) removing any free product (e.g., diesel) in monitoring wells.

Because the P&T system has been in cold-standby since March 2006, the total volume of water processed and activity of strontium-90 removed were unchanged from those reported in CY 2008:

- **Total processed groundwater since September 1995 startup:** 1,155.3 million L (over 305 million gal)
- **Total mass of strontium removed since September 1995 startup:** 1.83 Ci

## 4.2 Conceptual Site Model

This section describes the conceptual site model, including the general hydrogeologic conditions in the 100-N Area and changes in contaminant concentrations in monitoring wells.

### 4.2.1 Environmental Conditions

The hydrogeologic conditions in the 100-N Area and the main waste sites, as well as the known sources of contaminants found in groundwater, are presented in the following discussion.

#### 4.2.1.1 Geologic/Hydrologic Setting

The 100-N Area is underlain by the Hanford formation, the Ringold Formation unit E, and the RUM. The uppermost unit, the Hanford formation, is 6 to 23 m (19.7 to 75.5 ft) thick and underlies most of the area. The Hanford formation is open-framework, boulder-cobble gravel, sand, and silt deposited by cataclysmic flood waters from glacial Lake Missoula during the Pleistocene epoch (DOE/RW-0017). The Hanford formation is divided into three facies: (1) gravel-dominated, (2) sand-dominated, and (3) silt-dominated (DOE/RL-2002-39). The grains are typically sub-round to round gravel, and sub-angular to round in the sand grain fraction. The gravel-dominated facies typically is well stratified and contains little to no cementation (WHC-SD-EN-EV-027, *Hydrogeology of the 100-N Area, Hanford Site, Washington*; WHC-SD-EN-TI-132) but may contain discrete sand lenses. In a few places along the shoreline lower road, the Hanford formation is absent due to excavation and fill that was placed to build the roadway. The Ringold Formation underlies the entire area and is 5 to 20 m (16.4 to 65.6 ft) thick; it was deposited by fluvial-lacustrine (stream-lake) processes and is composed of a mix of fluvial gravels, fluvial sands, over bank deposits, paleosols, and lake deposits (WHC-SD-EN-EE-004; WHC-SD-EN-TI-011). Based on limited borehole information, the RUM underlies the entire decision unit and is 17 to 29 m (55.8 to 95.1 ft) thick; it is a relatively low-permeability unit and forms the base of the unconfined aquifer.

Most of the monitoring wells in the 100-N Area are completed in the upper portion of the unconfined aquifer, which is predominately in the Ringold Formation unit E. At high Columbia River levels, the aquifer can rise into the Hanford formation in wells along the shoreline and nearby inland wells. Three wells monitor the base of the unconfined aquifer in the lower Ringold Formation unit E. One well is completed in a fine-grained, sandy unit in the RUM, approximately 12 m (39 ft) below the water table. The properties of these formations influence the distribution and behavior of contamination in the subsurface. Within the 100-N Area, the vadose zone is composed mainly of the Hanford formation with portions of the Ringold Formation unit E in some areas. Figure 4-4 provides a generalized geologic cross section of the 100-N Area.

The surface of the Hanford formation/Ringold Formation unit E contact has a topographic high near the 116-N-1 facility, and the Ringold Formation unit E/RUM contact has a topographic low beneath and to the southwest of the Hanford/Ringold high spot. This depression or trough (2 to 2.5 m [6.6 to 1.6 ft] deeper than surrounding area) in the RUM runs from adjacent to the head end of the 116-N-1 facility to the river shoreline; it has created a preferential pathway at the base of the aquifer that closely mirrors where higher concentrations of contaminants have been found on the shoreline. Liquid wastes disposed to ground in the 100-N Area quickly migrated downward through the gravels of the Hanford formation, with very little lateral spreading until reaching groundwater. During operations, the water table was much higher and was located in the Hanford formation, forming a mound under the disposal facilities. Once in groundwater and the Ringold Formation, the wastes moved radially outward from the disposal sites and eventually followed groundwater flow to the Columbia River. When discharges ceased, the groundwater mound dissipated and left residual contamination in the vadose zone above groundwater. The *Integrated 100 Area Remedial Investigation Study/Work Plan, Addendum 5: 100-NR-1 and 100-NR-2 Operable Units* (DOE/RL-2008-46-ADD5) provides further details on the hydrogeologic conditions and how contaminants migrated through the vadose zones and groundwater.

#### **4.2.1.2 Major Ion Groundwater Chemistry**

An evaluation of the major ion chemical characteristics of the groundwater associated with the various contaminant plumes in the 100-N Area is presented in Appendix A and is summarized below.

The groundwater of the unconfined aquifer located predominately in the Ringold Formation unit E has pH values ranging from 6.70 to 8.44. Conductivity varies with location and contamination levels, ranging from 24.7  $\mu\text{S}/\text{cm}$  along the river to 1,813  $\mu\text{S}/\text{cm}$  in the highest diesel contamination well (199-N-18) (Figure 4-2). The DO concentrations also vary with location (near the river or inland) and are affected by both the apatite PRB treatment along the river (Figure 4-3) and diesel degradation in wells affected by the diesel plume. The DO ranges from 0.42 mg/L (well 199-N-173, presence of diesel degradation) to 15.01 mg/L inland (well 199-N-41, near the 116-N-3 Liquid Waste Disposal Facility). The ORP is also measured in several wells, especially those in the diesel plume and along the apatite PRB. The ORP is low in wells with reducing conditions created by either diesel degradation or the formation of apatite along the PRB, ranging from +4.6 mV to +444 mV. In the past, several wells along the apatite PRB have had negative ORP values, indicative of strong reducing conditions. Groundwater turbidity is low, generally less than 10 nephelometric turbidity units (NTU) in most wells. The only wells that exhibit higher turbidity values are those with low water levels and/or under the influence of diesel contamination. All of the samples evaluated can be classified as predominantly calcium bicarbonate waters that also contain notable but variable concentrations of sulfate and nitrate. The exception to this is wells in the existing apatite PRB, because the wells can be classified as more sodium/potassium-phosphate waters due to the chemistry of apatite formation and changes in groundwater concentrations related to that ongoing process.

Elevated levels of chloride are present in the 100-N Area, mainly in wells around the area of the known diesel plume and in wells near the 120-N-1 percolation pond and 120-N-2 surface impoundment (Figure 4-2). The DO concentration of this chloride-rich water was generally less than 5.0 mg/L, which is near the lower end of the range of DO values observed for the 100-NR-2 OU.

The major ion chemistry of groundwater sampled from wells located in the apatite PRB (Figure 4-3) is different than groundwater from elsewhere in the OU. Sodium, potassium, and alkalinity values are 2 to 10 times higher than those typically found elsewhere in the OU. The cation exchange of strontium for calcium involved in the formation of apatite not only reduced strontium and strontium-90 in solution but increased calcium concentrations sharply during the time of injection, from approximately 20,000 µg/L to as much as 87,700 µg/L. Currently, calcium concentrations have fallen back to pre-injection levels. The DO (3.8 mg/L) and sulfate concentrations are also lower in this area, consistent with ongoing formation of apatite in the PRB test area.

#### **4.2.2 100-N Area Groundwater Contaminants**

The following discussion summarizes the results of CY 2010 interim action groundwater monitoring in the 100-N Area. Wells and constituents monitored are defined in (1) the *Remedial Design Report/ Remedial Action Work Plan for the 100-NR-2 Operable Unit* (DOE/RL-2001-27) and modifications in TPA-CN-256, (2) the *100-N Area Integrated Groundwater Sampling and Analysis Plan* (DOE/RL-2009-58), and (3) the strontium-90 treatability test plan (DOE/RL-2005-96) and modifications in TPA-CN-271. The CERCLA sampling is conducted mainly in September, with selected wells also monitored in March. The RCRA sampling is conducted quarterly or semiannually under the Hanford Facility RCRA Permit (WA7890008967) according to the requirements of the *100-N Pilot Project: Proposed Consolidated Groundwater Monitoring Program* (BHI-00725) and the supplemental plan (PNNL-13914, *Groundwater Monitoring Plan for the 1301-N, 1324-N/NA, and 1325-N RCRA Facilities*). The analytical results from these other monitoring programs are also presented in this discussion where the data are useful for assessing rebound or defining plumes.

The principal groundwater COCs in the 100-N Area are strontium-90, tritium, chromium, manganese, sulfate, and TPHs (EPA/ROD/R10-99/112). Appendix D presents the sample results for CY 2010, as well as a historical summary of contaminant and co-contaminant monitoring results for wells and aquifer tubes.

##### **4.2.2.1 100-N Area Hydrogeologic Conditions**

Groundwater generally flows to the northwest toward the Columbia River beneath the 100-N Area. As the effects of extraction and injection dissipated after March 2006, the hydraulic gradient evened out. Figures 4-5a and 4-5b illustrate the March 2007 and March 2008 water tables, and the March 2009 and March 2010 water tables, respectively. When the 4 years of water table contours are reviewed collectively, the most noticeable feature is that the water table is flattening and elevation contour lines are moving slightly further inland each year, especially in the eastern portion of the 100-N Area. To the west, evidence exists of changes in the water table caused by the KR4 P&T injection and extraction wells located on the western edge of the 100-N Area. Where extraction is occurring, depressions occur in the water table; where injections are occurring, the water table elevations are displaced inland to the south. The goal is to keep chromium-contaminated groundwater from migrating into the 100-N Area and to emplace clean/treated water between the 100-N Area and the 100-K Area chromium plume. Chapter 3 provides further information regarding the water table in the 100-K Area.

During the spring months, the Columbia River elevation generally increases due to additional flow from snow melt runoff. Flow is regulated at the Priest Rapids Dam to provide irrigation water and to aid in fish migration. Figure 4-6 shows the monthly average river stage at the 100-N Area gauging station from

CY 2006 through CY 2010. The average river stage during CY 2010 was 117.76 m (386.34 ft). Table 4-1 compares the yearly average river stages over the last 6 years. The values in the table indicate that minor changes have occurred from year to year, and the percent difference is usually less than 1 percent. The yearly average for 2010 is slightly lower than all five of the previous years. During CY 2010, the river stage was highest between mid-June and early July, with the highest daily average of 120.19 m (395.32 ft) on June 22. The river stage was lowest in September and October, with the lowest daily average of 116.94 m (383.66 ft) on September 25, 2010.

Water levels in wells respond to changes in river stage. Wells on the river shore respond very quickly to changes in river levels; however, the response is more damped and delayed further inland from the river. It can take several days before a change in river level has an effect on wells further inland and unless the river level stays high or low for several days in a row, the effect may not be noticeable. Table 4-2 shows river-to-inland response for one set of water-level network wells in the 100-N Area during two low periods and one high period in river stages. Well 199-N-99A is on the 100-N Area shoreline, a couple of meters from the river and a couple of meters above the river. Wells 199-N-14 and 199-N-50 are further inland, approximately 150 and 420 m (492 and 1,378 ft), respectively, from the river; both wells are considerably higher in surface elevation (at least 20 to 22 m [66 to 72 ft] above river level). The effect of high and low river stage is also visible at the inland wells.

Figure 4-7 provides hydrographs for 2010 for the three wells listed in Table 4-2. The well closest to the river, 199-N-99A, has the most erratic water-level graph because it is highly influenced by river-level changes. Wells 199-N-14 and 199-N-50 have much smoother graphs; river-level changes are more gradual in these wells and take longer to occur.

#### **4.2.2.2 Contaminant Monitoring**

The main COC in the 100-N Area related to past operations is strontium-90. Other contaminants in groundwater at the 100-N Area include tritium, nitrate, TPH-diesel, and sulfate, as well as low levels of manganese, iron, and chromium.

The 116-N-1 (1301-N) and 116-N-3 (1325-N) Liquid Waste Disposal Facilities are the main sources of strontium-90 and tritium contamination in the 100-N Area. The 120-N-1 (1324-NA) percolation pond and 120-N-2 (1324-N) surface impoundment are the main sources of sulfate contamination. The diesel contamination in the 100-N Area is predominantly the result of spills that occurred in and around the N Tank Farm and 184-N day tank. Elevated manganese and iron are caused by the degradation of the diesel that remains in the groundwater. The isolated occurrence of chromium contamination is found in one well, 199-N-80, which has known screen corrosion.

##### **Strontium-90**

The size and shape of the strontium-90 plume changes very little from year to year, except in the vicinity of the apatite PRB treatment site. The plume extends from beneath the 116-N-1 and 116-N-3 facilities to the Columbia River at levels above the DWS (8 pCi/L) (Figure 4-8). The majority of the strontium-90 remaining in the unsaturated and saturated zones in the 100-N Area is present in the vadose zone above the aquifer. Far more strontium-90 is contained within the unsaturated zone than in the groundwater. Strontium-90 has a much greater affinity for sediment than for water (i.e., a high distribution coefficient), so its rate of transport in groundwater to the Columbia River is considerably slower than the actual groundwater flow rate. Strontium-90 is present in the upper portion of the unconfined aquifer, and concentrations decrease with depth; deeper wells are essentially free of strontium-90 contamination.

Strontium-90 trends in monitoring wells near the 116-N-1 facility show no obvious long-term decline in concentrations but do show significant variability related to water levels. Figure 4-9 shows the

strontium-90 concentrations and water levels in well 199-N-67, which has the highest level of contamination. Figure 4-10 shows strontium-90 concentrations and water levels in well 199-N-105A. When the water table rises, strontium-90 from the vadose zone is mobilized and concentrations in groundwater increase. Although not shown in Figures 4-9 and 4-10, concentrations increased in the mid-1990s, which correlated with several years of high river stage. Concentration peaks in 2006, 2007, 2008, 2009, and 2010 were correlated with periods when the water table was high.

After the extraction wells were shut off in March 2006, strontium-90 concentrations increased in the former cone of depression, as shown in Figure 4-11. Wells 199-N-75, 199-N-103A, 199-N-105A, and 199-N-106A are former P&T extraction wells. Concentrations were lower during P&T system operation; these lower values may possibly be caused by the lowering of the water table during extraction accessing a less contaminated portion of the aquifer. Note that strontium-90 contamination is concentrated in the upper portion of the aquifer. Strontium-90 concentrations in wells monitoring the 116-N-1 plume were higher in CY 2010 than in 1994 before P&T operations began (Table 4-3).

The P&T operations were stopped in March 2006. After this date (as shown in Figure 4-11 for trends of former extraction wells), concentrations increased sharply as water elevations rose. Strontium-90 levels have also declined from peak values in the late 1990s but remain higher than observed in 1994. Figure 4-11 provides trend plots for the former extraction wells. For example, in well 199-N-75, as the aquifer elevation increased from low of 116.35 m (381.72 ft) during P&T operations to 120.28 m (394.62 ft) in June 2006 after operations ceased, the strontium-90 concentrations increased from 241 pCi/L to 2,230 pCi/L during the last half of 2006. Similar trends are seen in wells 199-N-103A and 199-N-105A, with sharp increases in strontium-90 levels after P&T operations ceased. Furthermore, although contaminant levels have decreased in wells 199-N-103A and 199-N-105A, the trends are currently increasing and well above levels observed during P&T operations. However, well 199-N-106A displayed a decreasing trend with some fluctuations related to seasonal variations in the water table. This decreasing trend in well 199-N-106A began in January 2001 with a maximum of 4,750 pCi/L and steadily decreased to the 2009 value of 1,800 pCi/L. The reason for the continued decreasing trend in the well is unknown.

Along the Columbia River shoreline, strontium-90 concentrations increased to new highs in several aquifer tubes in 2005. These tubes are located in the core of the plume between wells 199-N-123 and 199-N-147, which also corresponds to the location of the apatite PRB. Aquifer tube NVP2-116.0 detected the highest strontium-90 concentration at 2,870 pCi/L (estimated as one-half gross beta concentration, September 28, 2005). Until the apatite PRB injections started in spring 2006, concentrations remained consistent. During injections from 2006 through 2008, strontium-90/gross beta concentrations in these aquifer tubes had much fluctuation. Immediately after injections, the concentrations increased dramatically, which was due to the high ionic strength of the injection fluid. Many cations, metals, and anions temporarily went into solution, thus increasing concentrations in groundwater. The effect was temporary and values returned to pre-injection levels within 2 to 4 weeks. The highest value recorded in an aquifer tube was at NVP2-116.0m on July 24, 2008, during the high-concentration apatite injection tests. The measured gross beta on that date was 150,000 pCi/L, which gives an estimated strontium-90 concentration of 75,000 pCi/L. By October, the values were down to pre-injection levels. Figure 4-12 shows the strontium-90 trend plots for aquifer tubes N116Array-3A, N116Array-4A, and N116Array-6A. Figure 4-13 shows the strontium-90 trend plot for aquifer tube NVP2-116m. The plots clearly show increases when the P&T system was shut down, increases after apatite injections, and decreases following injections. Overall, a significant decrease in strontium-90/gross beta contamination has occurred along the shoreline since installation of the apatite PRB. Figure 4-14 shows the strontium-90 plume along the 100-N Area shoreline near the apatite PRB.

Porewater samples were collected in December 2010 in accordance with the *Sampling and Analysis Plan for the 100-NR-2 Operable Unit River Pore Water Investigation* (DOE/RL-2010-69). The goal was to estimate impacts of the 100-N Area contamination of the Columbia River, especially within the most biologically active zone of the river substrate. The data are currently being reviewed, and a report documenting the results of this sampling effort is being prepared.

### **Tritium**

The tritium plume has diminished since 1991 when effluent discharge to the 116-N-3 facility ceased (Figure 4-15). During CY 2010, none of the wells had concentrations exceeding the DWS (20,000 pCi/L). The maximum concentration was 17,500 pCi/L in well 199-N-32, which is near the 116-N-3 facility. Table 4-4 lists the tritium concentrations before, during, and after P&T operations, as well as the percentage change between 1994 and 2010, as well as 2005 and 2010. Nearly all of the wells showed decreased concentrations. Well 199-N-16 showed increases from both pre-P&T (1994 to 2010) and during P&T (2005 to 2010) operations. The cause for this increase is uncertain, but it may be related to the influx of treated groundwater from 100-K Area P&T injection wells to the west. Wells 199-N-74, 199-N-99A, 199-N-119, 199-N-120, and 199-N-121 showed increases in tritium from 2005 to 2010. Well 199-N-74 is located considerably south of the 116-N-1 and 116-N-3 facilities and showed decreased tritium concentrations between 1994 and 2005. In CY 2010 sampling, tritium concentrations have again begun to increase; the source of the increased tritium is unknown at this time. Wells 199-N-99A, 199-N-119, 199-N-120, and 199-N-121 are located along the Columbia River shoreline, where the known tritium plume intersects the river. Since shutdown of P&T operations in 2006, higher concentration tritium-contaminated groundwater has been moving toward the Columbia River from the former 116-N-1 and 116-N-3 facilities. The shoreline aquifer tubes had undetectable tritium concentrations. As seen in wells 199-N-119, 199-N-120, and 199-N-121 (completed next to each other along the shoreline in the upper, middle, and lower unconfined aquifer, respectively), tritium is found throughout the unconfined aquifer.

### **Chromium**

Although a chromium plume associated with the 100-KR-4 OU exists at the southern boundary of the 100-NR-2 OU, a distinct plume associated with the local source OU is not present at the 100-N Area. However, chromium (and at times, hexavalent chromium) contamination does occur in isolated wells. In most cases, when present, levels are at or near the detection limit. Table 4-5 lists chromium concentrations before, during, and after P&T operations, as well as the percentage change between 1994 and 2010 and between 2005 and 2010.

One well in the 100-N Area has chromium concentrations above the DWS (100 µg/L). Well 199-N-80, which is completed in a thin, confined aquifer in the RUM, had a chromium concentration in CY 2010 of 192 µg/L in a field-filtered sample, which is a typical value for the well. A down-hole video survey of this well in 2001 showed screen corrosion, which may be the cause of the elevated chromium (per PNNL groundwater annual reports, 2001 and 2004). Stainless-steel corrosion is caused by sulfur impurities present in the metal. These small sulfur inclusions cause depletion of the chromium from the surrounding metal, and a "pit" is created in the metal where this process is occurring (Nature 415, 770-774, 2-14-2002). In a stainless-steel well where this corrosion is occurring, chromium and sulfate are released into solution. When a groundwater sample is taken from a well in this instance, similar trends are noted in chromium and sulfate concentrations. Figure 4-16 provides the trend plot for chromium and sulfate in well 199-N-80. The two trends appear to mirror each other, which may indicate that the elevated chromium concentrations are the result of stainless-steel corrosion occurring in the well.

Hexavalent chromium samples collected in CY 2010 show that the concentration of filtered chromium and hexavalent chromium are essentially the same (Table 4-6). The relative percent difference (RPD)

between filtered total chromium and unfiltered hexavalent chromium is well within analytical method variances and error. A second well, 199-N-74, has chromium detections below the DWS but above detection limit in 2010. Table 4-7 lists the detected chromium values in well 199-N-74 from the CY 2010 sampling events. The unfiltered hexavalent chromium and filtered chromium samples are essentially the same, indicating that the filtered portion of the chromium sample shows hexavalent chromium. The RPDs were calculated for the differences between total chromium (filtered) and hexavalent chromium (unfiltered) for each of the analytical methods used; the difference was greater between the two values for Method 200.8 than for Method 6010. The duplicate unfiltered hexavalent chromium samples were in good agreement for both sampling events.

Several documents describe the relationship between filtered total chromium samples and hexavalent chromium samples, including the following:

- DOE/RL-2008-01, *Hanford Site Groundwater Monitoring for Fiscal Year 2007*
- DOE/RL-2008-66, *Hanford Site Groundwater Monitoring for Fiscal Year 2008*
- WHC-SD-EN-TI-302, *Speciation and Transport Characteristics of Chromium in the 100D/H Areas of the Hanford Site*

The other detected total chromium concentrations (above the detection limit and not flagged) in the unconfined aquifer in CY 2010 were 12.9 and 12.6 µg/L in samples from wells 199-N-50 and 199-N-51, respectively, located northeast of the 116-N-1 and 116-N-3 facilities. These wells are not located near any of the three major liquid waste sites. Chromium concentrations have never been high in the wells, but the wells will continue to be monitored to determine if this is an ongoing detection. In addition to continued monitoring for total chromium (unfiltered and filtered) in the 100-N Area, the monitoring program will add hexavalent chromium analyses to all wells to determine if any potential issues exist in regard to chromium in 100-N Area wells. The four compliance wells located along the existing apatite PRB were also monitored and are included in Table 4-5; all four wells were nondetect for total chromium in CY 2010.

### ***Manganese and Iron***

In CY 2010, manganese continued to exceed secondary DWS (50 µg/L) in several wells affected by current or past petroleum contamination: 199-N-16 (106 to 1,120 µg/L), 199-N-18 (5,920 to 9,650 µg/L), 199-N-19 (70 µg/L), 199-N-57 (50 to 130 µg/L), 199-N-167 (1,310 µg/L), 199-N-169 (249 µg/L), 199-N-170 (145 µg/L), 199-N-171 (1,200 µg/L), 199-N-172 (3,200 µg/L), and 199-N-173 (4,520 to 4,570 µg/L). In CY 2010, iron also continued to exceed its secondary DWS (300 µg/L) in several wells affected by current or past petroleum contamination: 199-N-16 (498 to 2,910 µg/L), 199-N-18 (21,200 to 67,500 µg/L), 199-N-19 (941 µg/L), 199-N-57 (515 to 846 µg/L), 199-N-172 (2,940 µg/L), and 199-N-173 (585 to 829 µg/L). Natural biodegradation of the hydrocarbons creates reducing conditions, which increases the solubility of metals such as manganese and iron from the well casing and/or aquifer sediment. All of these wells also have low DO and ORP measurements, which also indicate reducing conditions in groundwater.

Other wells also exceeded the secondary DWS for both manganese and iron, but it is not as clear why these wells had higher concentrations of the two metals, as the wells are not influenced by past or present TPH contamination. These wells include 199-N-26 (550 µg/L manganese; 19,700 µg/L iron), 199-N-32 (63.8 µg/L manganese; 376 µg/L iron), and 199-N-46 (157 µg/L manganese; 961 µg/L iron). Wells exceeding only the secondary DWS for iron were 199-N-2 (421 µg/L), 199-N-67 (465 µg/L), 199-N-73 (442 µg/L), and 199-N-147 (310 to 315 µg/L). It is uncertain why iron concentrations are high in these

wells; some have older carbon-steel casings and some have stainless-steel casings. In all of these wells, the DO and ORP measurements are within normal levels and do not indicate reducing conditions.

### **Nitrate**

The current nitrate plume map is shown in Figure 4-17. Nitrate concentrations continued to exceed the DWS (45 µg/L, as nitrate ion) in many wells in CY 2010. Table 4-8 lists the nitrate concentrations before, during, and after P&T operations, as well as the percentage change between 1994 and 2010 and between 2005 and 2010. The highest concentrations continued to be in wells 199-N-2, 199-N-67, and 199-N-105A near the 116-N-1 facility, with maximum CY 2010 concentrations of 224, 500, and 109 mg/L, respectively. Nitrate concentrations are higher in the upper aquifer wells than the deep wells, except in well trio 199-N-119, 199-N-120, and 199-N-121, where nitrate concentrations increase with depth.

### **Sulfate**

The sulfate plume map for the 100-N Area shows the highest concentration near the 120-N-1 percolation pond, which is the source of the contamination (Figure 4-18). Over time, the plume has drifted downgradient to other parts of the 100-N Area. Table 4-9 lists sulfate concentrations before, during, and after P&T operations, as well as the percentage change between 1994 and 2010 and between 2005 and 2010. Only one of the wells or aquifer tubes sampled in CY 2010 had sulfate concentrations above the 250 mg/L secondary DWS. Well 199-N-18, which is at the center of the diesel contamination plume, had a value of 504 mg/L; it is likely that this high concentration is due to the presence of free product in the well (see discussion below on TPH monitoring for further information). The next highest concentration was in well 199-N-165, which monitors the 120-N-1 percolation pond and introduced sulfate and sodium into 100-N Area groundwater, and is also the source of the sulfate plume. The concentration in well 199-N-165 was 161 mg/L. Other wells with elevated sulfate levels (less than 100 mg/L) are located downgradient of the source (120-N-1 percolation pond), near the 116-N-1 and 116-N-3 facilities. The sulfate plume is migrating with groundwater and has spread under other portions of the 100-N Area. Sulfate concentrations were low in the aquifer tubes (Table 4-9).

### **Total Petroleum Hydrocarbon**

Well 199-N-18 monitors the portion of the 100-N Area where a 300,000 L (79,252 gal) petroleum leak occurred during the 1960s (N Tank Farm). The highest reported value for TPH-diesel range was 630,000 mg/L in March 2003 (with 2.54 cm [1 in.] of free product in the well). Figure 4-19 provides a current TPH plume map. As shown the figure, it is evident that the plume is emanating from the N Tank Farm, which is the location of the original large spill. Over time, the plume has moved toward the Columbia River following normal groundwater flow patterns. The plume currently intersects the river near wells 199-N-173 and 199-N-96A. Determining dissolved hydrocarbons in well 199-N-18 is difficult because of the way the well must be sampled. An open container is lowered into the well below the floating product, which disturbs the surface of the water, and nonaqueous liquid may become entrenched in the sample. Two sample sets were collected from well 199-N-18 in CY 2010, and the results varied widely. The concentration for a sample collected in July was 420,000 µg/L, and a sample collected in December was 41,000 µg/L. The highest value measured in 2009 was 16,000 µg/L. The large increase in concentration from 2009 to 2010 was because free product was not removed from the well during the entire year.

A passive treatment method to remove diesel from well 199-N-18 was used in October 2003 and continued through part of 2009. This approach was chosen because the layer of floating petroleum was too thin for removal by active remediation methods. The passive method uses a polymer (Smart Sponge®) with a molecular structure that selectively absorbs petroleum from the surface of the water (i.e., acting as

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Smart Sponge® is a registered trademark of ABTech Industries, Troutman, North Carolina.

a sponge) while the device floats in the air/hydrocarbon/water interface. A bundle of two Smart Sponge bilge skimmers, 22.86 cm by 10.16 cm by 5.08 cm (9 in. by 4 in. by 2 in.), is lowered into the well to soak and absorb floating petroleum product. This assembly is changed out every 2 months, at which time the skimmers are removed, weighed, and replaced with a new pre-weighed bundle. All information collected from this operation was tracked in the work control system and evaluated by the 100-N Area technical lead for annual reporting purposes (Table 4-10).

In June 2010, it was discovered that a Smart Sponge had broken apart in the well. The polymer from the sponge was smeared up the entire length of casing to ground surface when the sponge assembly was removed. In early July, well maintenance personnel performed the first cleaning of the well. Several additional attempts were made to clean the well as much as possible. The sponges were not reinstalled; instead, an attempt was made to determine a different method to place the sponges into the well and prevent this incident from reoccurring. As of the end of 2010, the sponges had still not been reinstalled in well 199-N-18. Increased TPH-diesel range concentrations were caused by free product floating in the well because the free-floating product was not being removed. The well may also have been influenced by the Washington Closure Hanford (WCH) bioventing test being performed immediately to the south of the well.

Other wells with TPH-diesel detections were as follows: 199-N-96A (170 and 200 µg/L), 199-N-167 (4,600 µg/L), 199-N-169 (1,100 µg/L), 199-N-170 (360 µg/L), 199-N-171 (2,800 µg/L), 199-N-172 (25,000 µg/L), 199-N-173 (2,100 µg/L), 199-N-346 (3,700 µg/L), and 199-N-348 (3,800 µg/L). Four aquifer tubes also had detections for TPH-diesel range: C6132 (190 µg/L), N116mArray-0A (570 µg/L), C6135 (910 µg/L), and N116mArray-1A (220 µg/L). Further characterization of petroleum contaminants in the unsaturated subsurface was performed in conjunction with drilling of seven bioremediation wells. The results of vadose zone mapping are presented in the *Bioremediation Well Borehole Soil Sampling and Data Analysis Summary Report for the 100-N Area Bioremediation Project (UPR-100-N-17)* (WCH-370).

Evidence of low levels of hydrocarbon contamination have been observed in wells 199-N-3 and 199-N-19 in the past (PNNL-14187, *Hanford Site Groundwater Monitoring for Fiscal Year 2002*) but not during CY 2010. These wells are located near well 199-N-18 and have been influenced by contamination from the same source in the past.

Near the N Reactor building, well 199-N-16 also had evidence of petroleum contamination, which is believed to be from a separate past source (184-N day tank spills). The TPH-diesel range was measured at 79 µg/L (just above the detection limit) in CY 2010.

### 4.3 Strontium-90 Treatment Technologies

The following subsections provide additional information expansion of the apatite PRB, apatite infiltration testing at the apatite PRB, jet injections along the apatite PRB, and phytoextraction.

#### 4.3.1 Expansion of the Apatite Permeable Reactive Barrier

The DOE agreed to construct and evaluate the effectiveness of a PRB using apatite sequestration technology as part of the CERCLA RI/FS process and consistent with the 100-NR-1 and 100-NR-2 OU interim ROD (EPA/ROD/R10-99/112; Tri-Party Agreement Change Control Form M-16-06-01). Strontium-90 sequestration using this technology occurs through injection of a calcium-citrate-phosphate solution. Once injected, biodegradation of the citrate results in apatite precipitation and strontium-90 substitutes for calcium in the mineral matrix when apatite crystallization occurs.

The original apatite treatability test site covers approximately 91.4 m (300 ft) along the 100-N Area shoreline (Figure 4-3). Forty-five monitoring points are associated with this site, including injection/

barrier wells, monitoring wells, and aquifer tubes (Table 4-11). Sixteen wells comprise the PRB. Four monitoring wells are located along the PRB, between the Columbia River and the injection/barrier wells. Two pilot test sites (PT#1 and PT#2) are located at each end of the PRB and around the two end injection/barrier wells (199-N-138 and 199-N-137, respectively), which contain smaller diameter monitoring wells surrounding the end injection/barrier wells (Figure 4-3).

Strontium-90 contamination in the 100-N Area is primarily absorbed to sediments by IX (99 percent absorbed and 1 percent in solution in the groundwater) in the upper portion of the unconfined aquifer and the lower vadose zone. Although primarily absorbed, strontium-90 is still considered a high mobility risk because it is mobilized by seasonal river stage increases and also plumes of higher ionic strength water relative to groundwater (PNNL-16891, *Hanford 100-N Area Apatite Emplacement: Laboratory Results of Ca-Citrate-PO<sub>4</sub> Solution Injection and Sr-90 Immobilization in 100-N Sediments*).

Most of the wells and aquifer tubes showed a significant increase in most cations/metals and anions in solution following an injection due to the higher ionic strength solution that was injected. Cation/metal and anion concentrations generally decrease over time following an injection. Some variability is seen regarding how the different monitoring points react over the length of the PRB based on hydrologic conditions (PNNL-17429, *Interim Report: 100-NR-2 Apatite Treatability Test: Low-Concentration Calcium-Citrate-Phosphate Solution Injections for In Situ Strontium-90 Immobilization*).

The highest concentration of gross beta was seen in aquifer tube NVP2116.0 (Figure 4-13). The gross beta concentration was a result of injections in nearby wells. High levels of total dissolved solids in injected solutions temporarily mobilized strontium-90 by IX. The maximum gross beta concentration was 150,000 pCi/L in tube NVP2-116.0m on July 24, 2008, equating to 75,000 pCi/L strontium-90. Gross beta concentrations dropped from their peak by early September but remained higher than levels before injection. The last measured gross beta and strontium-90 values at NVP2-116.0 were 2,600 and 1,200 pCi/L, respectively, on December 29, 2010. The highest gross beta level in a well was 51,000 pCi/L in well 199-N-162 on July 15, 2010 (Figure 4-20). The last measured gross beta and strontium-90 values in this well were 63.0 and -3.50 pCi/L (nondetect) for the first sample and 90.0 and 38.0 pCi/L for the duplicate sample on August 16, 2010. Declining gross beta values are the general trend for most of the samples taken through the end of 2010, with some exceptions. Many factors affect the chemistry of the soil and water interaction along the PRB, including changes in river level and differences in hydraulic conductivity and soil matrix, both locally and over the length of the PRB.

Barrier injections completed prior to spring 2008 used low-concentration formulations of calcium-citrate-phosphate solution to emplace approximately 0.136 mg PO<sub>4</sub>/g of sediment or 0.34 mg apatite/g of sediment. To determine if apatite was forming in the soil matrix, tests were conducted on actual PRB sediments collected when six additional injection/barrier wells (199-N-159 through 199-N-164) were installed in spring 2008. Samples were taken at 0.3 m (1 ft) intervals, from 2.1 to 7.6 m (7 to 25 ft) below ground surface in each well, for a total of 120 samples. Phosphate profiles with depth in all six wells clearly showed a much greater proportion of apatite in the Hanford formation than in the Ringold Formation; this was likely due to the larger volume of solution that permeated the Hanford formation during injections in the fully screened wells. Phosphate extraction data from these tests indicate that at a radial distance of approximately 4.6 m (15 ft) from the adjacent injection wells, the Hanford formation received an average treatment of 110 percent and the Ringold Formation an average treatment of 30 percent of the targeted apatite content (PNNL-17429). Studies are ongoing to determine the progress and mechanisms of strontium-90 attenuation.

Subsequent monitoring data have been encouraging, indicating that apatite is being formed and strontium-90 is being adsorbed as designed. Performance monitoring at the existing PRB continued

after the high-concentration injections ended in July 2008. Samples were taken every other month for approximately one year, with quarterly monitoring performed through the second year. The last samples required by the test plan were taken in August 2010, and the results indicated that strontium-90 values in all wells remained at a 90 percent reduction from pre-injection values. Some locations are still gradually trending downward, but trends at other locations have flattened out or are trending slightly upward. Performance monitoring at the PRB will continue on a biannual schedule, occurring at low and high river-level conditions in April/May and October/November, respectively.

An evaluation was performed for sediment core samples collected in November 2009, approximately one year after the high-concentration treatments to quantify the amount of apatite formation resulting from the sequential low, followed by high-concentration treatments performed to date. The average phosphate for three boreholes (both the Hanford formation and Ringold Formation) was 68 percent of the injected mass (PNNL-19524, *Hanford 100-N Area In Situ Apatite and Phosphate Emplacement by Groundwater and Jet Injection: Geochemical and Physical Core Analysis*; PNNL-19572).

Based on the results of treatability testing, the apatite technology seems to be a promising remedial option. As a result, the DOE proposed in June 2009 to amend the existing interim ROD for the 100-NR-1 and 100-NR-2 OUs (EPA/ROD/R10-99/112) to include expansion of the existing apatite PRB to a total length of approximately 762 m (2,500 ft) in the aquifer and the vadose zone as an interim remedial action. To support selection of this interim remedy, an assessment of the potential impacts of the injected chemistry on threatened and endangered species was conducted by PNNL and reported in *Assessment of Apatite Injection at 100-NR-2 for Potential Impact of Threatened and Endangered Species* (PNNL-SA-75348). The resulting amendment to the interim ROD was issued in September 2010 (EPA et al., 2010) and allows for the proposed expansion.

To prepare for the expansion, 171 new wells were installed along the 100-N Area shoreline. These wells cover the entire length of the shoreline where the strontium-90 plume intersects the Columbia River. The 146 injection wells were installed approximately 4.6 m (15 ft) apart and were designed to cover both the Hanford formation and Ringold Formation when installed. The injection wells alternate between shallow Hanford formation (approximately 4.6 m [15 ft] deep) and deep Ringold Formation completions (approximately 7.6 m [25 ft] deep). Along with the injections wells, 25 additional deep Ringold Formation completion (approximately 7.6 m [25 ft] deep) monitoring wells were installed at spacing equal to the existing four PRB monitoring wells (approximately 25.9 to 27.4 m [85 to 90 ft] apart). Table 4-11 lists the new wells included in the apatite PRB expansion.

Implementation of the interim remedy apatite barrier expansion will be conducted under a revision to the 100-NR-2 OU interim action remedial action/remedial design work plan (DOE/RL-2001-27), which was submitted to Ecology on March 25, 2011.

Plans to optimize the apatite barrier technology prior to full-scale expansion will initially move forward under two approved design optimization studies: barrier expansion design optimization studies (DOE/RL-2010-29, *Design Optimization Study for Apatite Permeable Reactive Barrier Extension for the 100-NR-2 Operable Unit*), and jet injection design optimization studies (DOE/RL-2010-68, *Jet Injection Design Optimization Study for the 100-NR-2 Operable Unit*).

#### **4.3.2 Apatite Infiltration Test at the Apatite Permeable Reactive Barrier**

Apatite injections treat strontium-90 contamination in the aquifer and lower portions of the vadose zone, but much of the contamination is in the upper portion of the vadose zone. PNNL conducted a study of apatite infiltration to treat vadose zone contamination under the DOE Environmental Management (EM-22) Technology Program. The study took place in fall 2010 at the infiltration gallery test site,

approximately 5 m (16.4 ft) past the downriver end of the existing apatite PRB (Figure 4-3). Two tracer tests were conducted using sodium bromide tracer. The results of the test were as follows:

- Application rate of tracer at 0.7 cm/hour
- Tracer arrivals at water table (3 to 3.7 m [10 to 12 ft] below the base of the infiltration gallery) after approximately 5 days
- Advancement rate of 0.6 m/day (2 ft/day)

A report on the results of the apatite infiltration test is currently being prepared and will be issued in 2011.

#### 4.3.3 Jet Injections Along the Apatite Permeable Reactive Barrier

An additional pilot-scale test was conducted in December 2009 to evaluate potential strategies for using jet injection technology to emplace an apatite PRB in the vadose zone and upper unconfined aquifer. The test consisted of three distinct treatment zones using three different media: a phosphate-only solution, pre-formed apatite, and the same phosphate solution with pre-formed apatite. The pilot-scale test was conducted upstream of the existing apatite PRB, with the objective of the jet injection pilot-scale demonstration two-fold: (1) evaluate the ability of the technology to deliver the different material/chemical solutions into the vadose zone and upper unconfined aquifer within three distinct treatment zones in the 100-N Area shoreline; and (2) evaluate the ability of the methods to install a PRB in the vadose zone containing a specific amount of apatite (4 mg apatite/g sediment) (SGW-47062, *Treatability Test Report for Field-Scale Apatite Jet Injection Demonstration for the 100-NR-2 Operable Unit*).

Both test objectives were met. The jet injection technology was successfully used to emplace three different media in the vadose zone and upper unconfined aquifer. Collection and analysis of post-injection sediment cores enabled evaluation of apatite emplacement within the vertical sediment column. Apatite emplacement at concentrations equal to or greater than 4 mg apatite/g sediment was observed in the sediment cores in all three test plots (SGW-47062; PNNL-19524).

Immediate plans to optimize this apatite barrier technology prior to full-scale expansion will initially move forward under two approved design optimization studies: (1) the barrier expansion design optimization study (DOE/RL-2010-29), and (2) the jet injection design optimization study (DOE/RL-2010-68).

#### 4.3.4 Phytoextraction

Phytoextraction of strontium-90 may be a potential remediation technology (polishing step) along the riparian zone of the Columbia River as part of an apatite PRB to reduce transport of strontium-90 to the river. The process uses coyote willows (*Salix exigua*) to extract strontium-90 from the vadose zone soil and aquifer sediments (phytoextraction) and to filter strontium-90 (rhizofiltration) from the shallow groundwater along the riparian zone of the Columbia River (PNNL-19120, *100-N Area Strontium-90 Treatability Demonstration Project: Phytoextraction Along the Riparian Zone – Field Treatability Study*). The initial test plot was installed in the 100-K Area to allow testing under uncontaminated conditions (i.e., no strontium-90) and to test the methodology along an area of shoreline where the slope was gentle and no large areas of rock (rip-rap) were present (e.g., 100-N Area).

The results of the test performed at the 100-K Area for 2007 through 2009 are summarized below:

- During the 3 years of testing, the trees survived multiple flooding events (including total immersion), no trees were uprooted or displaced, and most survived the entire 3-year period.

- Biomass (leaves, twigs, and smaller branches) production followed a typical growth curve for the first 2 years and went to a logarithmic/exponential rate in the third year.
- No intrusion of large or small herbivores occurred at the test plot over the 3-year period. The site had chain-link fencing (with smaller mesh screening around the bottom 0.61 m [2 ft] of fencing, which also extended underground) surrounding the plot.
- Observed calcium and strontium concentrations found in harvested biomass suggest that the trees could prove effective in removing strontium-90 in the riparian zone.
- Harvested biomass is controlled and disposed in accordance with approved radiological and waste management procedures.

Further information on this study and the results are provided in PNNL-19120. Plans to test this technology along the 100-N Area shoreline were initiated in CY 2010. However, as part of the RI/FS activities, this technology will be evaluated for future use.

#### 4.4 Characterization of Petroleum Contamination

Several wells and aquifer tubes in the 100-N Area have had detections of TPH. Figure 4-19 shows the TPH plume as it currently exists in the 100-N Area. It is clear from the shape and direction of the plume that the main source of contamination is the N Tank Farm. The plume is moving toward the Columbia River and intersects the river by aquifer tubes NI16mArray-0A and C6135. Appendix D of the *Assessment of the Strontium-90 Contaminant Plume Along the Shoreline of the Columbia River at the 100-N Area of the Hanford Site* (PNNL-16894) discusses evidence for this contamination. Low levels (less than 1 mg/L) of TPH-diesel range were reported in several tubes around Array 0A. Workers observed small amounts of oil sheen during installation of these tubes in January 2007. During drilling of monitoring wells for the apatite PRB in 2005, diesel product was recovered from wells 199-N-122 and 199-N-123 (WMP-27771, *Borehole Summary Report for Wells 199-N-122 [C4954] and 199-N-123 [C4955]; 100-NR-2 Operable Unit*).

New well 199-N-173 was installed in spring 2009 for testing the TPH remediation technologies. The well is located approximately 120 m (394 ft) southwest (upriver) of the apatite PRB and also serves as the last upriver monitoring well for the planned apatite PRB expansion. Samples were collected from this well when it was drilled in February 2009 and three times since. The results of the TPH sampling are provided in Table 4-13.

Well 199-N-173 also had soil samples taken in several intervals during drilling, and those results are reported in Table 4-13. Figure 4-21 shows the TPH-diesel range concentrations with depth in the well. The diesel is on top of water table; when the well was drilled, the diesel was detectable in the soil above water table and a couple of meters into the water table. As can be noted in the figure, the largest detection of TPH-diesel was just above water table; by 8 m (26.2 ft) in depth, it was nondetectable and continued to be nondetectable to total depth in the well.

WCH installed seven bioremediation wells to perform bioremediation/bioventing pilot tests in early 2009. The seven wells were completed as two shallows vadose zone wells, and five wells that were completed to the groundwater (with screen at the top of the unconfined aquifer). The wells for this study are listed in Table 4-14. Bioremediation involves the use of micro-organisms to degrade contaminants, with the goal of obtaining nonhazardous final products. The micro-organisms produce natural catalysts (enzymes) that degrade organic compounds forming carbon dioxide, methane, water, and mineral salts. Enhanced bioremediation involves the introduction of nutrients (typically nitrogen and phosphate) and electron

donors or acceptors (oxygen) to enhance the biodegradation provided by the naturally occurring microbes indigenous to the site. Water is also frequently introduced to the subsurface to bring soil moisture content into the optimum range for bioremediation. Upon the introduction of air, nutrients, and, if necessary, water into the subsurface, the population of indigenous microbes thrives and uses the TPH as its food source.<sup>2</sup> The result was that the hydrocarbons are degraded aerobically, or oxidized, to carbon dioxide and water (WCH-323, *Sampling and Analysis Instruction for installation of UPR-100-N-17 Bioremediation Wells and Performance of Bioventing Pilot Tests*).

Bioventing pilot tests will be conducted to evaluate contaminant removal rates and the distribution of air flow within the contaminated zone. The tests will consist of soil vapor measurements, respirometry tests, and air injection tests. Soil vapor monitoring is performed to determine the baseline concentrations of oxygen, carbon dioxide, and volatile hydrocarbons. Air injection tests will be performed to evaluate soil permeability and the supply of adequate oxygen to the contaminated soil. The respirometry tests are performed to provide estimates of in situ biodegradation rates (WCH-323). This work began at the Waste Information Data System UPR-N-17 site in the fall of 2010 and continues in 2011. A draft report on the test progress was issued in early 2011 but was not yet available for use in this report.

Data from the installation of the seven wells listed in Table 4-15 identified zones of TPH contamination based on the sample results. All wells had high concentrations of TPH in a zone starting about 17 m (55 ft) below ground surface and extended to the groundwater table in the unconfined aquifer. The distance from well 199-N-166 to the bioremediation well closest to the river (199-N-172) is approximately 61 m (200 ft). Well 199-N-172 is located on the approximate azimuth as the currently accepted direction of the hydraulic gradient for groundwater in the unconfined aquifer. Since the TPH concentration did not noticeably decrease from wells 199-N-166 to 199-N-172, it may be assumed the zone of TPH contamination extends beyond 61 m (200 ft) and may extend to the Columbia River. The sampling data currently do not assist in fully defining the lateral and upgradient boundaries of the TPH-diesel contamination in the vadose zone (WCH-370).

Groundwater samples have been collected in conjunction with the WCH bioventing tests from the five deep wells in use by WCH. Two sets of samples were collected from two of the five wells in fall 2009, and an additional set of samples was collected from all five wells in spring 2010. The results of those samples are shown in Table 4-15. All five wells had detectable concentrations of TPH-diesel range. The data were used in conjunction with data from CHPRC sampling events to construct the first diesel plume map for the 100-N Area. The plume map shown in this document is the second generation of that map, as many changes in concentration occurred between the samples listed in Table 4-15 and the recent groundwater samples from later in 2010.

## 4.5 Conclusions

Conclusions for the 100-NR-2 OU are as follows:

- **RAO #1:** Maintain beneficial uses of the Columbia River and aquifer by reducing contaminant concentrations in 100-NR-2 OU groundwater.

The goal is to protect potential human and ecological receptors at the river from exposure to radiological and nonradiological contaminants present in the unconfined aquifer. The P&T system was not effective at reducing strontium-90 flux to the Columbia River; therefore, the P&T system

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<sup>2</sup> The addition of water to the vadose zone is currently not anticipated for the application of this technology at the UPR-100-N-17 waste site.

was placed in cold-standby status on March 9, 2006, when the pumps were shut off. The effects of the pump shutdown are summarized below.

**Results:**

- Strontium-90 concentrations increased in some former P&T extraction wells after the pumps were shut off. The reason for this increase may be related to increasing aquifer elevations after the pumps were stopped. As the effects of the cone of depression decreased, samples were collected from a shallower, more contaminated interval within the aquifer, causing strontium-90 concentrations to increase sharply. Three of the four former extraction wells are still trending upward but at a slower rate than immediately after P&T operations ceased in 2006. The fourth well is trending downward.
- Strontium-90 concentrations in some aquifer tubes and wells temporarily increased near the apatite PRB in both 2007 and 2008 in response to the apatite barrier emplacement injections. The concentrations in these aquifer tubes and wells are now lower than pre-injection levels by at least 90 percent. However, strontium-90 levels are currently above 8 pCi/L in these aquifer tubes.
- Shutting off the P&T extraction wells did not result in higher tritium concentrations. Tritium concentrations continued to decrease throughout most of the plume. Concentrations in aquifer tubes were very low, from nondetect to hundreds of picocuries per liter.
- Chromium, manganese, and sulfate concentrations remained within previously established ranges, with some wells displaying sharply increasing trends in nitrate.
- The TPH concentrations increased in 2010 due to the limited removal of free product. Work will continue in 2011 to reinstall the Smart Sponges in well 199-N-18, which should help decrease concentrations in the well and surrounding wells.
- **RAO #2:** Obtain information to evaluate technologies for strontium-90 removal and evaluate ecological receptor impacts from contaminated groundwater.

**Results:** The DOE installed a 91.4 m (300 ft) apatite PRB near the Columbia River shoreline in 2006, 2007, and 2008. A jet injection test was performed along the shoreline with favorable results. Expansion of both the existing PRB in the saturated zone and installation of the jet-injected PRB in the vadose zone are planned. Additionally, reinjections at the current 91.5 m (300 ft) PRB are needed and are planned following completion of the initial expansion efforts. Further phytoextraction testing at the 100-N Area is also planned. Results of the infiltration gallery tracer test will be available in 2011 and the technology will be evaluated for potential further use.

- **RAO #3:** Prevent destruction of sensitive wildlife habitat. Minimize disruption of cultural resources and wildlife habitat in general and prevent adverse impacts to cultural resources and threatened or endangered species.

**Results:** The interim remedial action ROD (EPA/ROD/R10-99/112) establishes a variety of institutional controls that must be implemented and maintained throughout the interim action period. These provisions include the following:

- Access control and visitor escorting requirements
- Signage providing visual identification and warning of hazardous or sensitive areas (new signs were placed along the river and at major road entrances at each reactor area)

- Excavation permit process to control all intrusive work (e.g., well drilling and soil excavation)
- Regulatory agency notification of any trespassing incidents

The effectiveness of institutional controls established in the interim ROD for the 100-NR-2 OU (EPA/ROD/R10-99/112) was evaluated and summarized for implementation and effectiveness in 2003. The *2004 Site Wide Institutional Controls Annual Assessment Report for Hanford CERCLA Response Actions* (DOE/RL-2004-56) presents the results for the current review. In summary, the report determined that institutional controls were maintained to prevent public access as required.

## 4.6 Recommendations

The recommendations for the 100-NR-2 OU are as follows:

- Continue to monitor strontium-90 plumes, focusing on the former extraction wells and the portion of the plume near the Columbia River.
- Additional apatite barrier emplacement injections are needed at the current 91.5 m (300 ft) PRB to further reduce strontium-90 concentrations in the groundwater to the target level of 8 pCi/L in the hyporheic zone.
- Implement the approved design optimization studies for barrier expansion in the saturated and vadose zones along the Columbia River shoreline.
- Four years have passed since the 100-N Area P&T extraction wells were placed in cold-standby status, so frequent monitoring for rebound is no longer required. The frequency of monitoring for former extraction wells was reduced to annually.
- Continue to monitor co-contaminants.
- Continue to evaluate the extent of possible shoreline water quality impact related to the diesel spill that occurred circa 1963. Aquifer tubes at the upstream end of the array will continue to be sampled for TPH and related contaminants. Work has begun for characterizing and testing of remediation technologies for the petroleum contamination plume; WCH is testing bioventing technology in seven wells installed in the diesel plume near UPR-N-17.

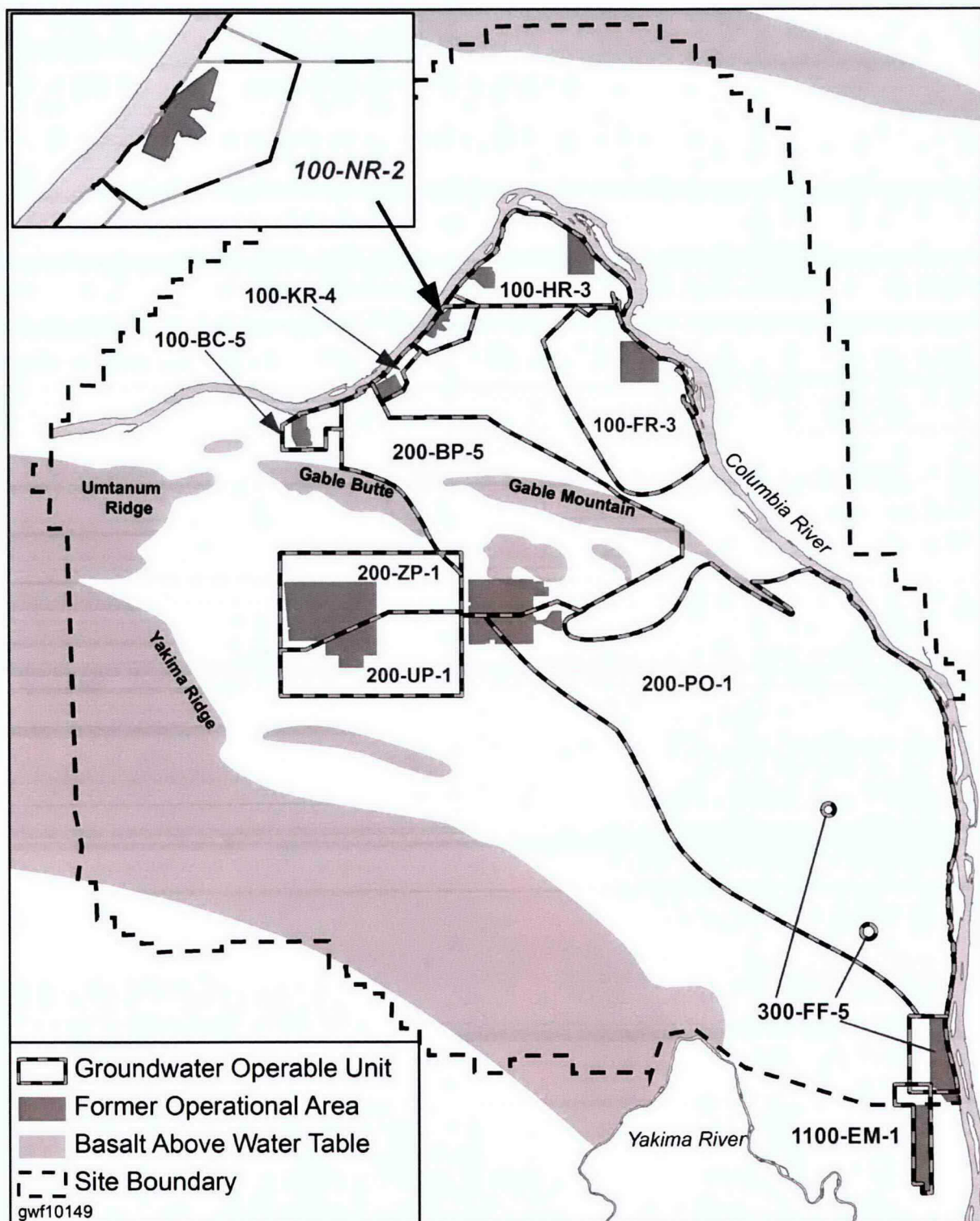


Figure 4-1. Location of the 100-NR-2 OU

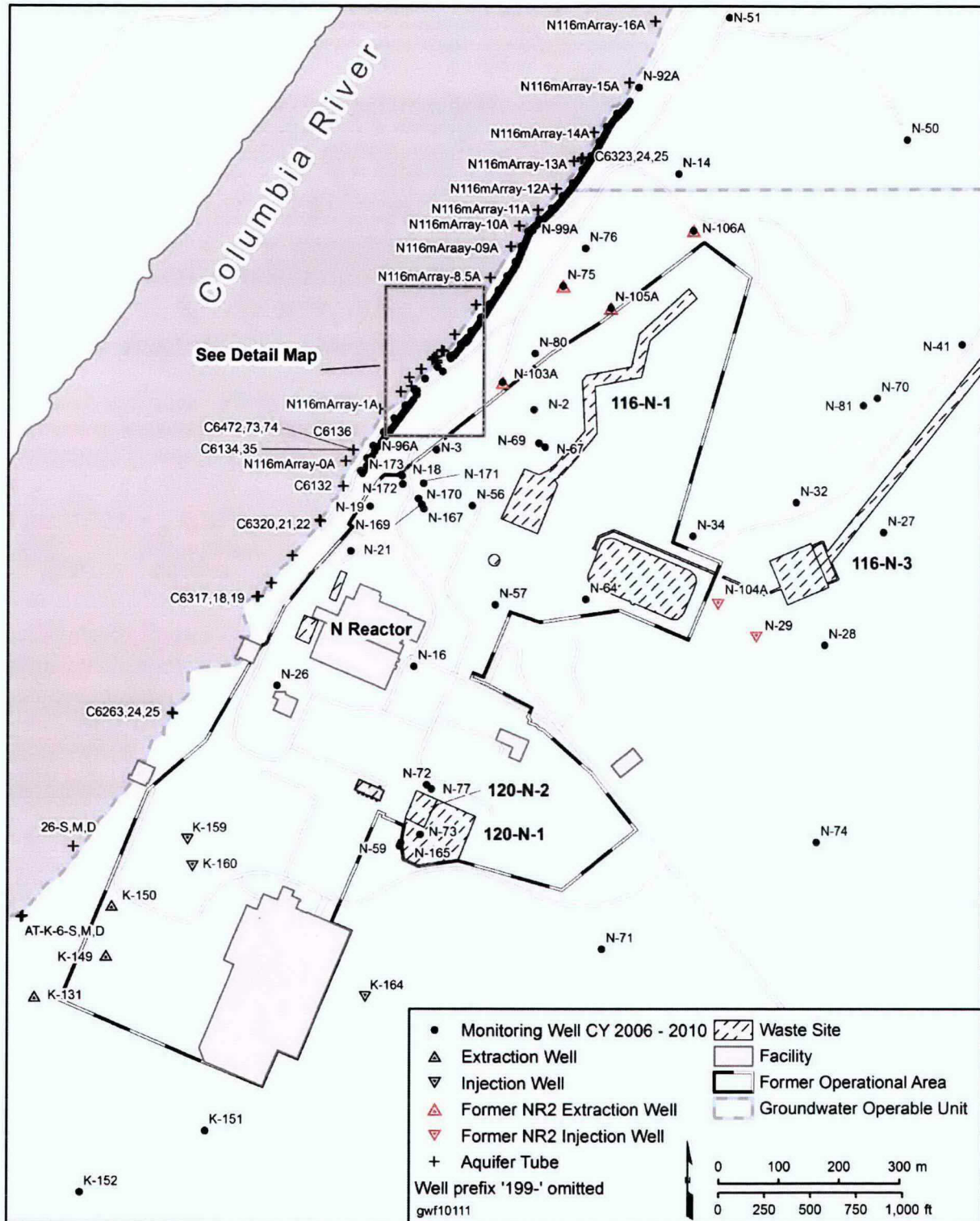


Figure 4-2. 100-NR-2 OU Wells

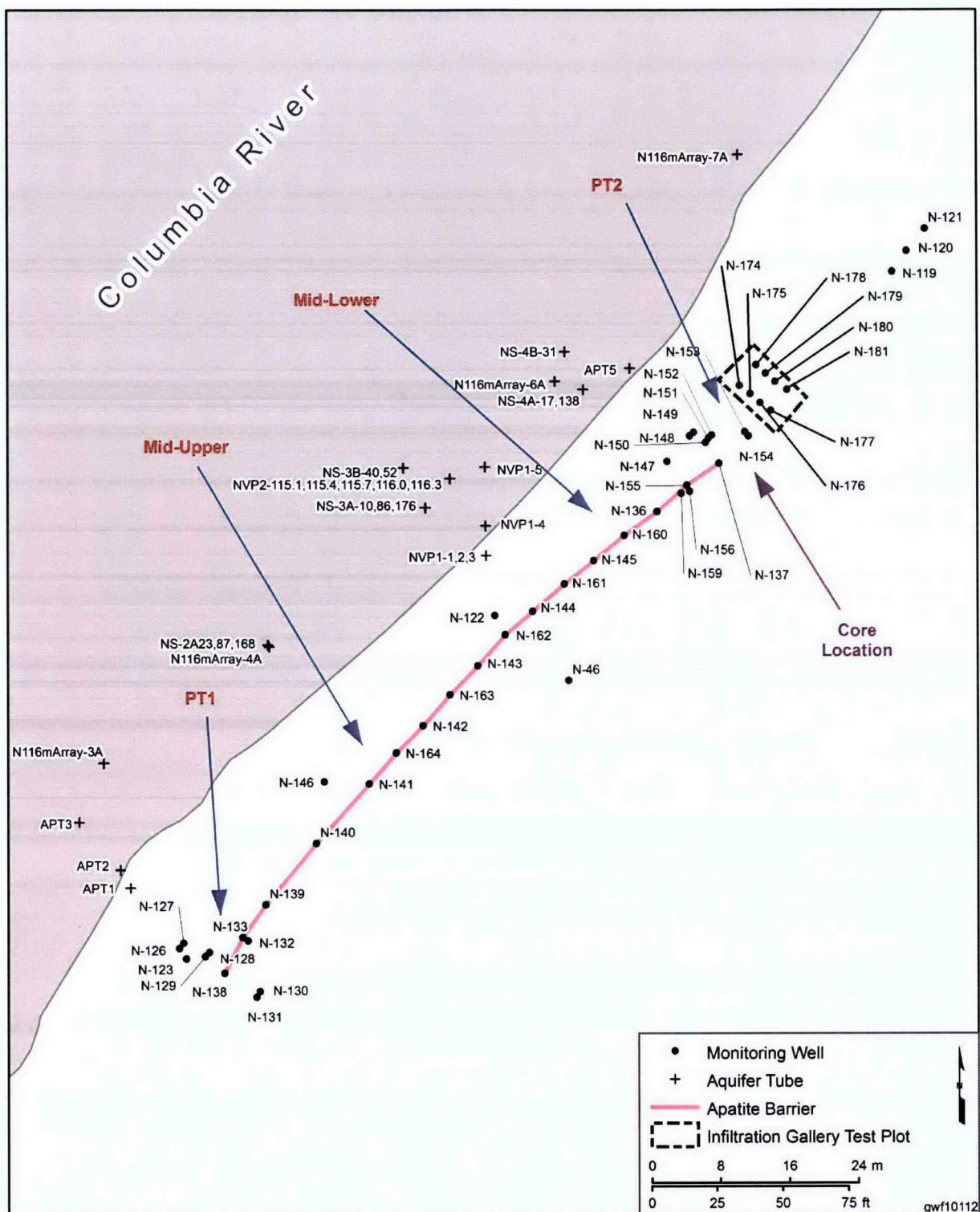


Figure 4-3. Aquifer Tubes and Monitoring Wells Along Columbia River Shoreline

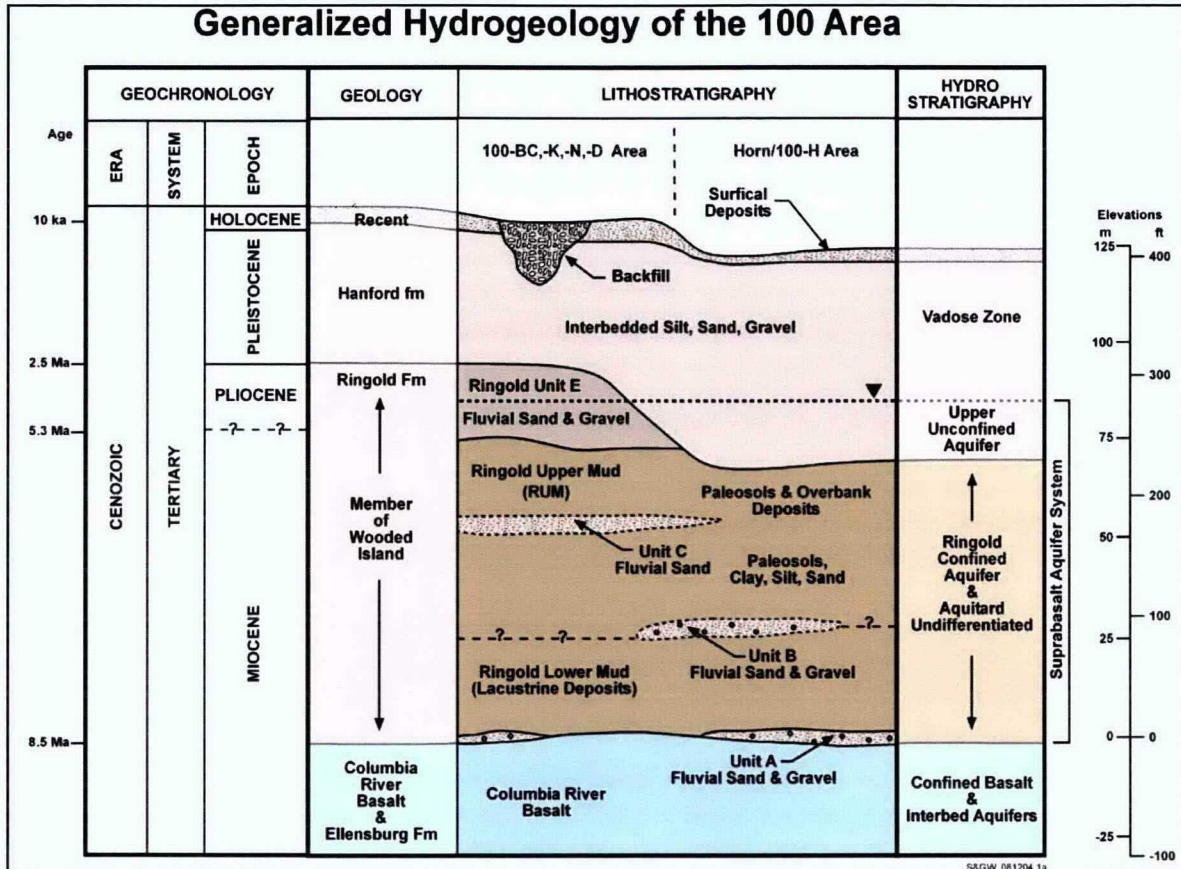


Figure 4-4. Generalized Geologic Cross Section of 100-NR-2 OU

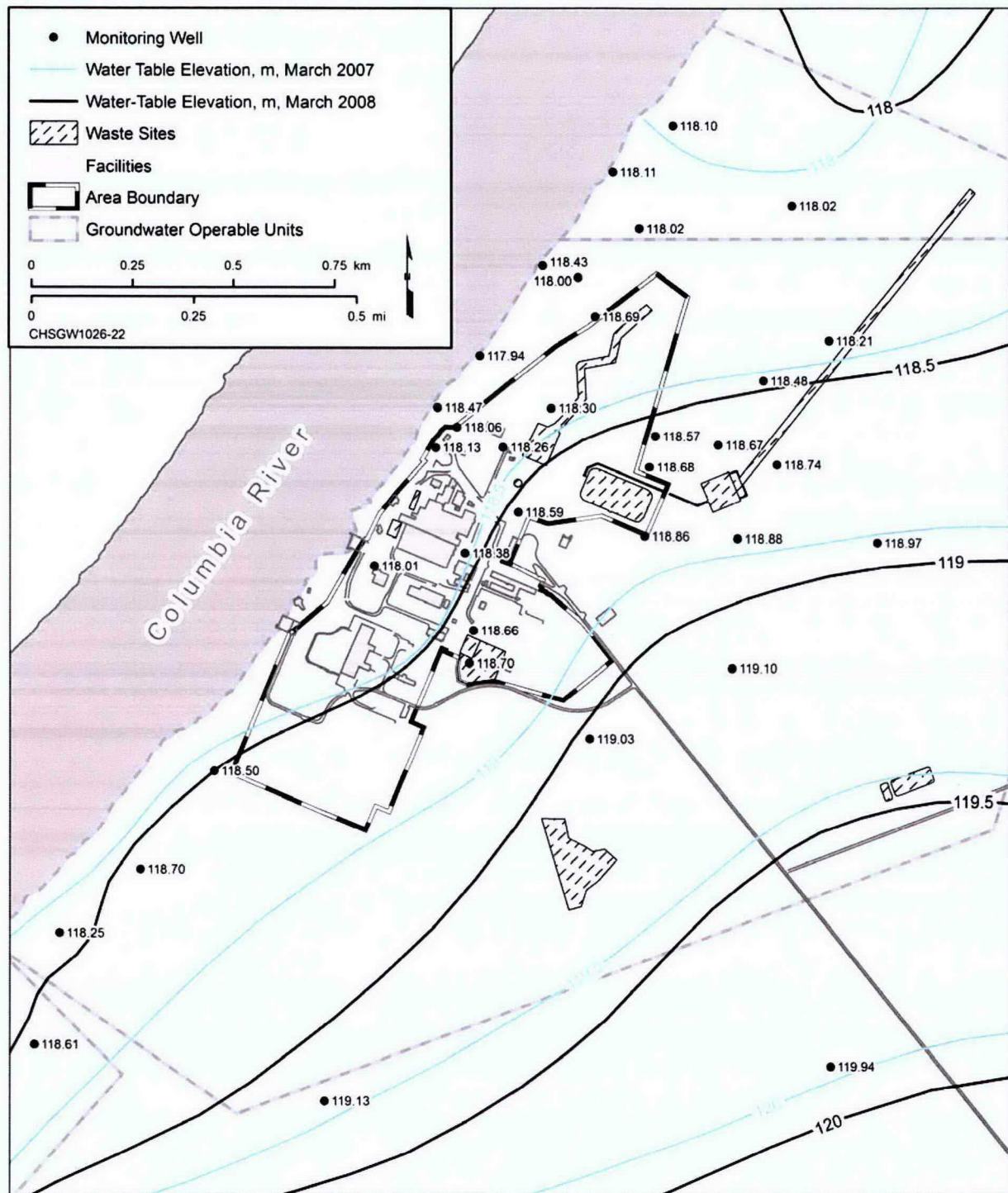
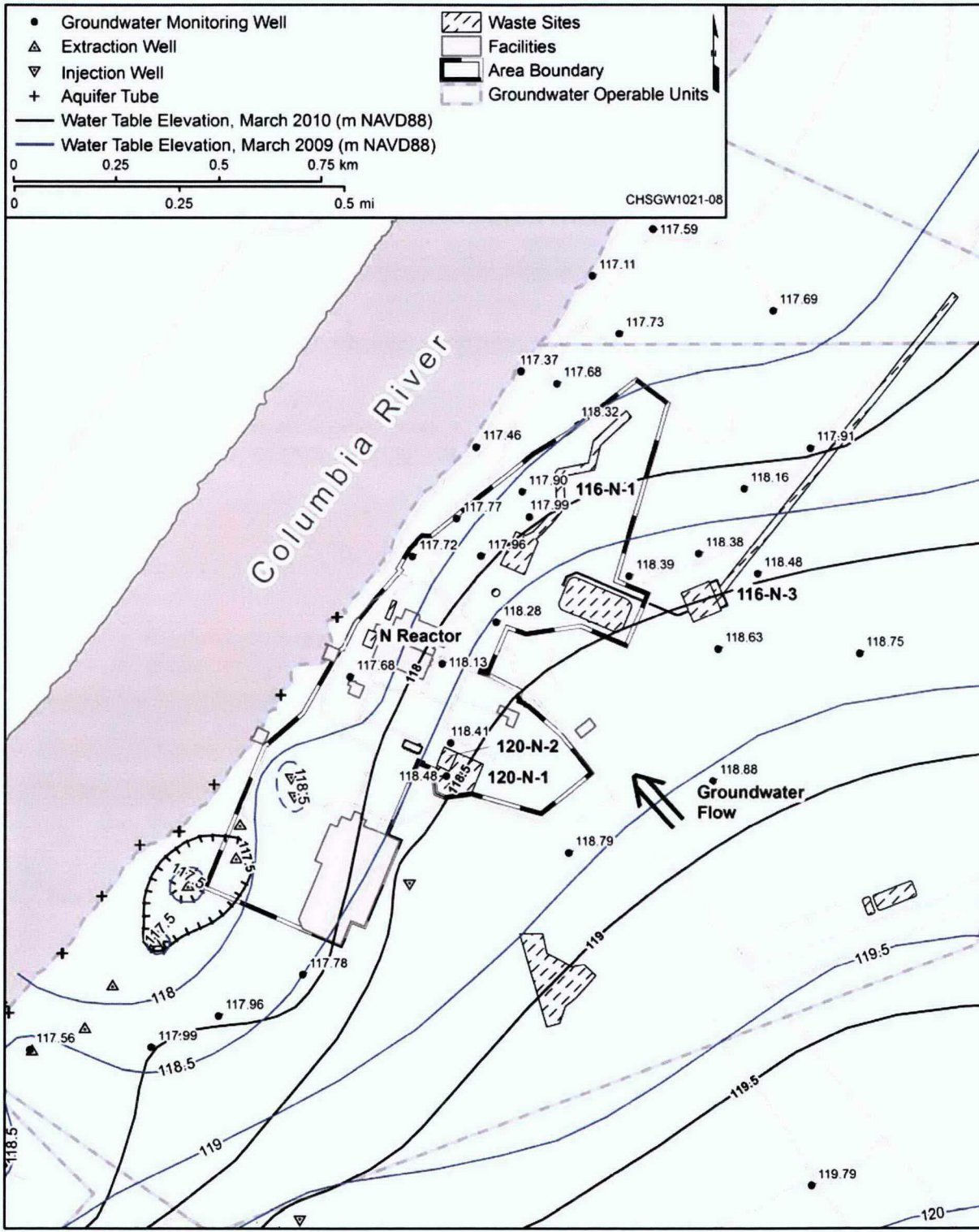


Figure 4-5a. 100-N Area Water Table Map, March 2007 and March 2008



**Figure 4-5b. 100-N Area Water Table Map, March 2009 and March 2010**

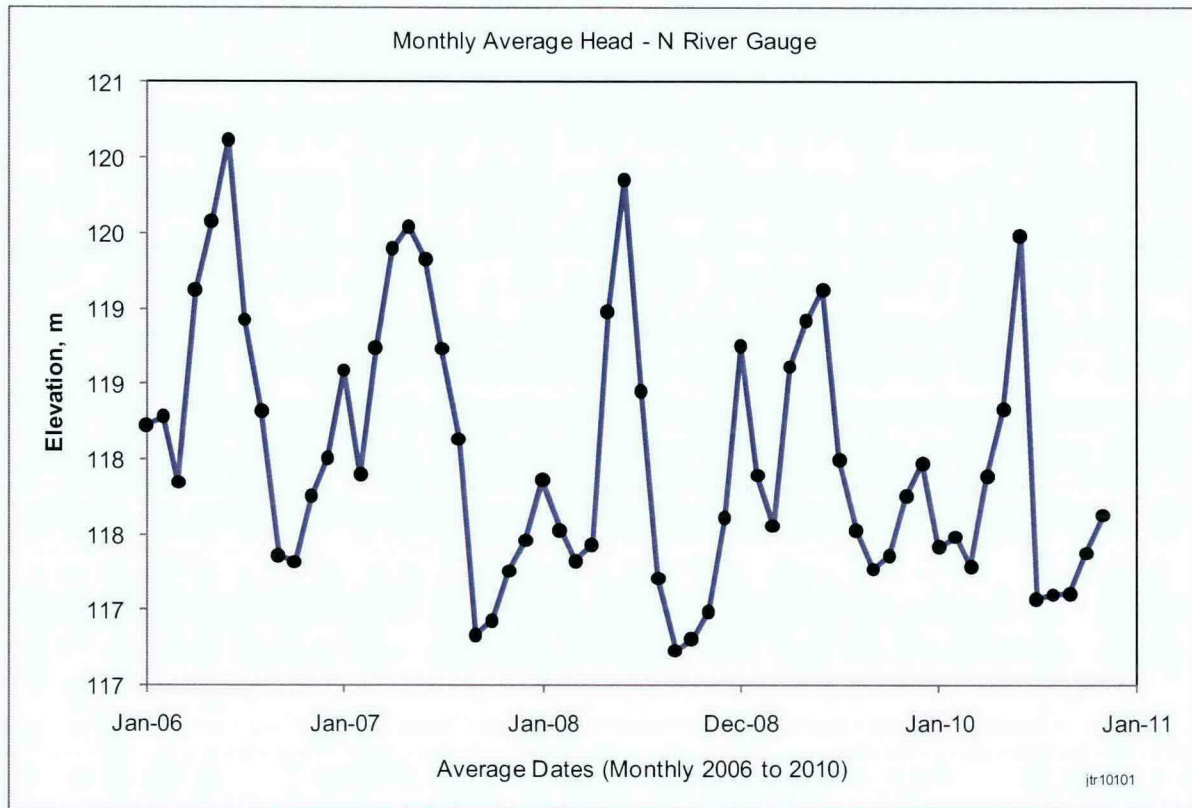


Figure 4-6. Elevation of Columbia River at 100-N Area, 2006 to 2010

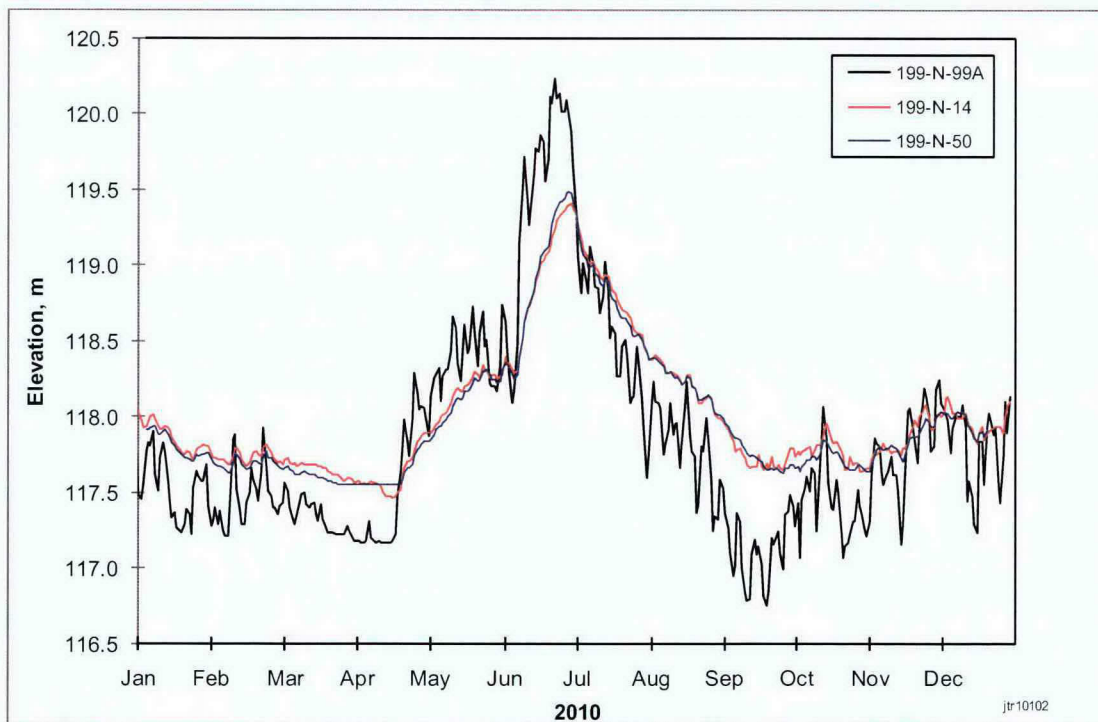


Figure 4-7. 2010 Daily Average Water Level in Wells 199-N-99A, 199-N-14, and 199-N-50

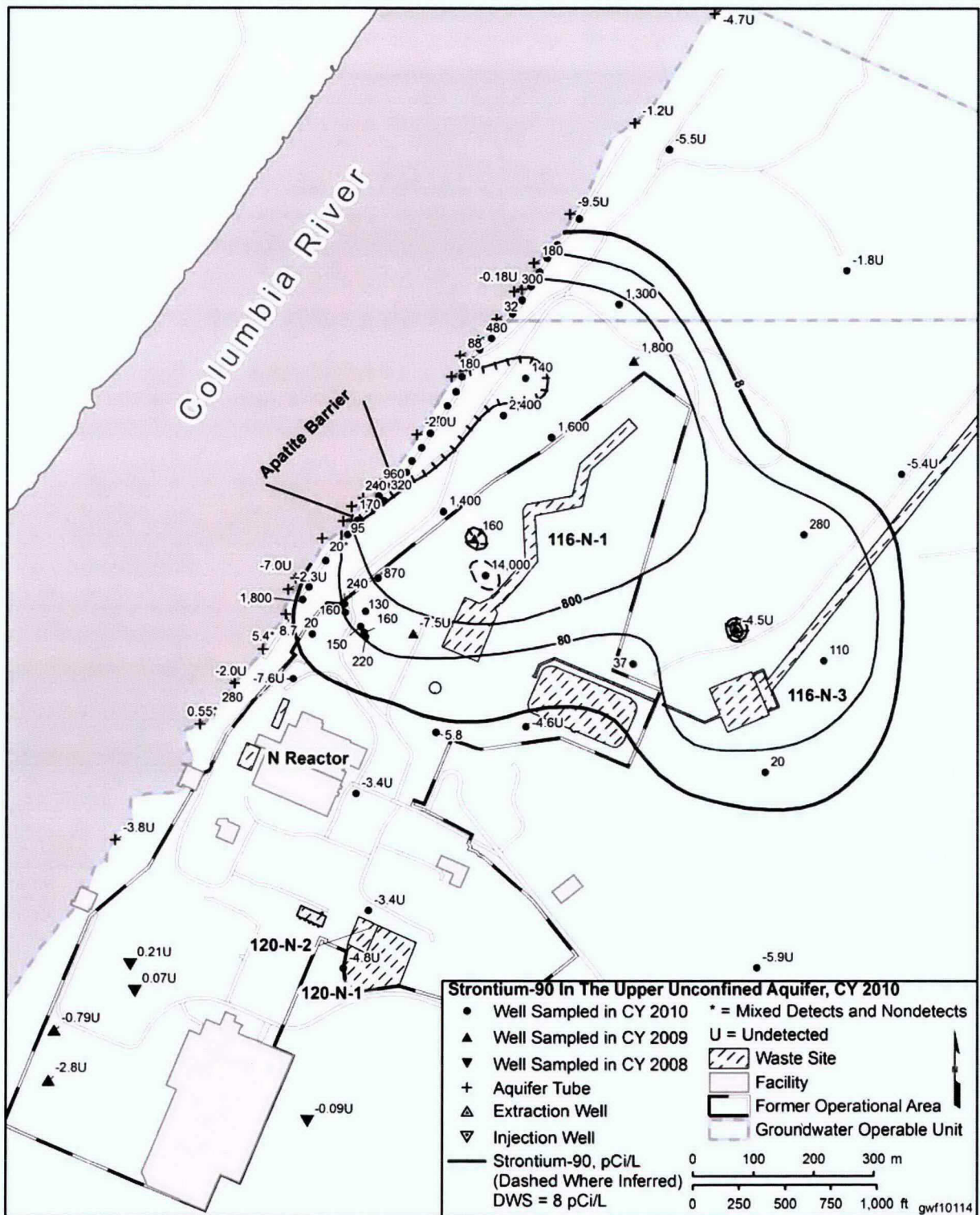


Figure 4-8. Strontium-90 Plume Map for 100-N Area

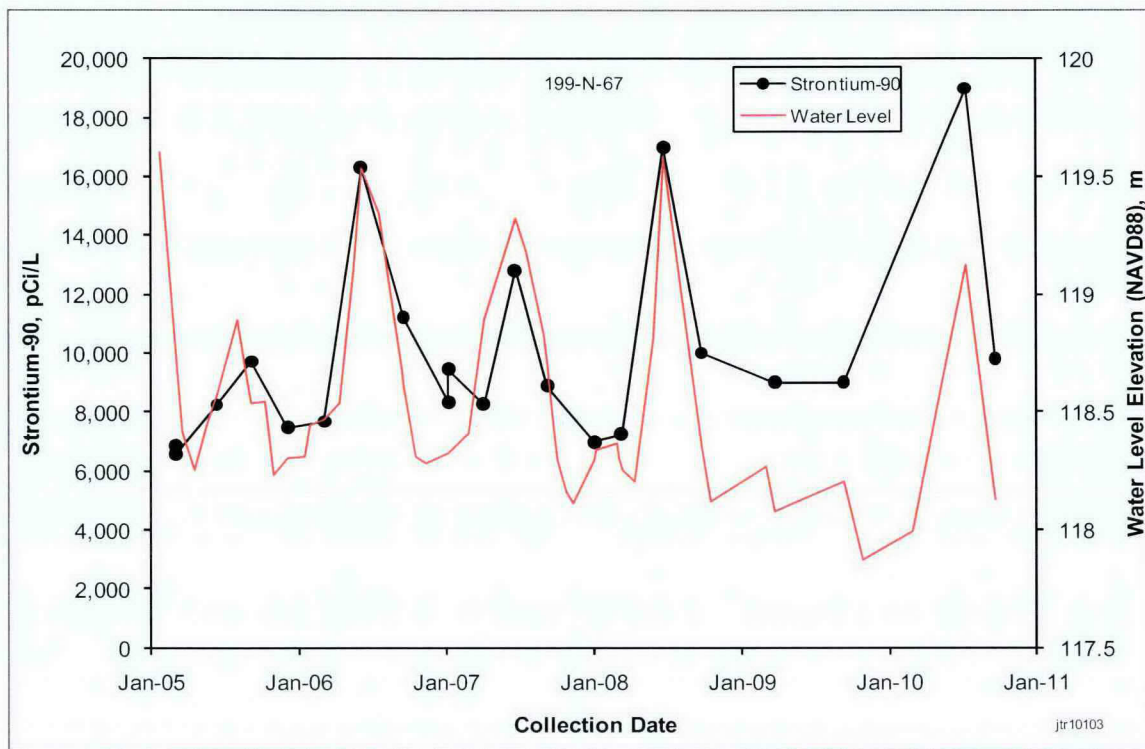


Figure 4-9. Strontium-90 Trend Plot and Water Levels for Well 199-N-67

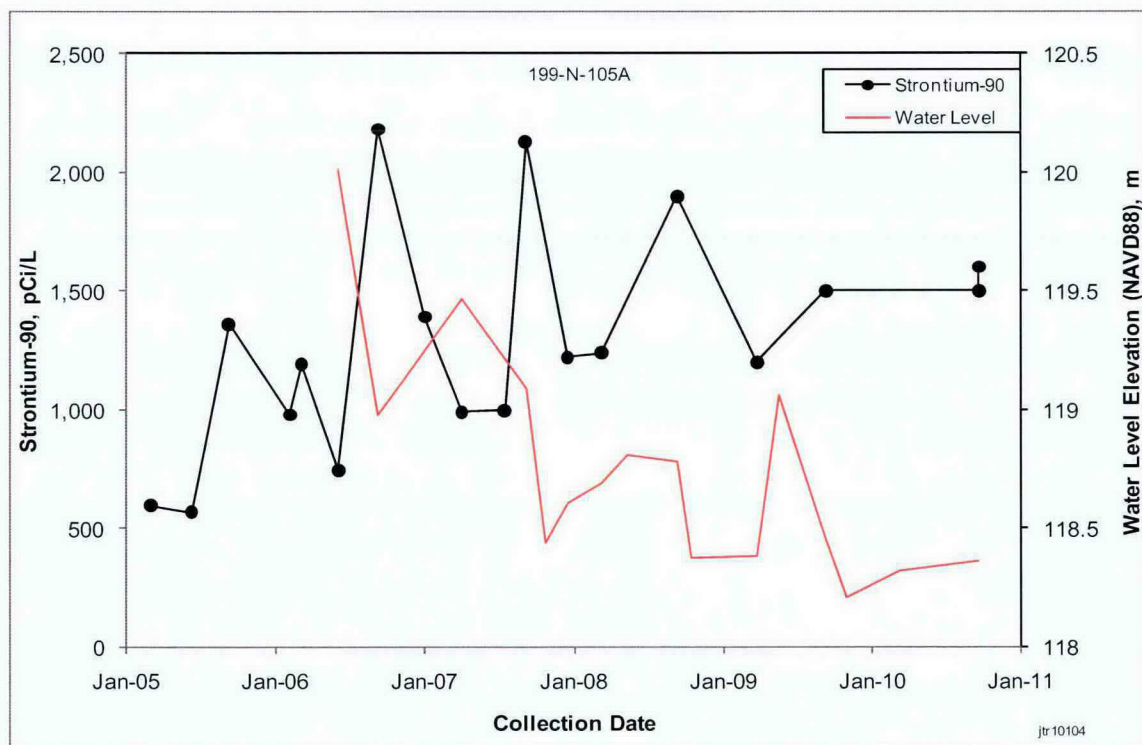


Figure 4-10. Strontium-90 Trend Plot and Water Levels for Well 199-N-105A

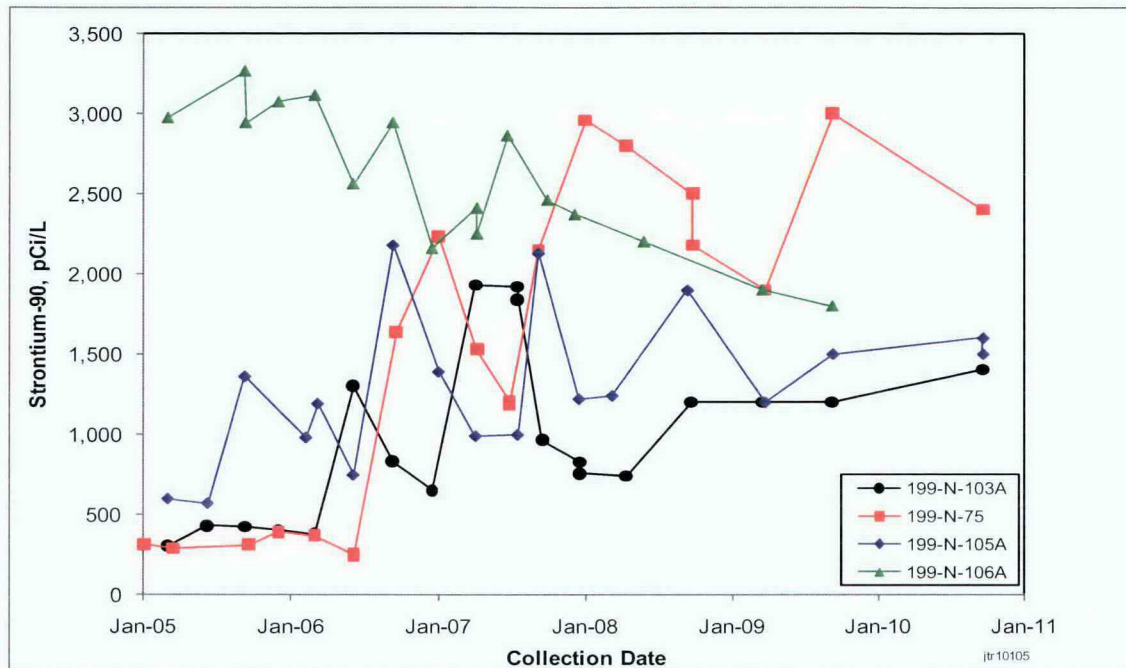


Figure 4-11. Strontium-90 Trend Plots for the Four Former P&T Extraction Wells

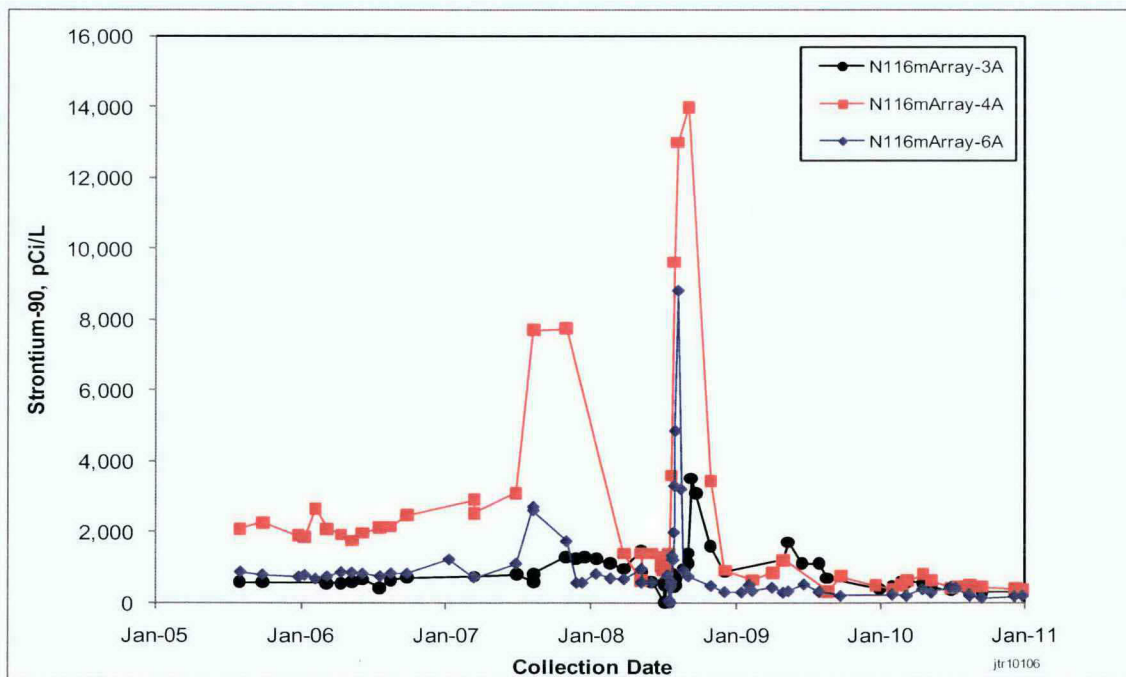


Figure 4-12. Strontium-90 Trend Plots for Aquifer Tubes Adjacent to the Apatite PRB

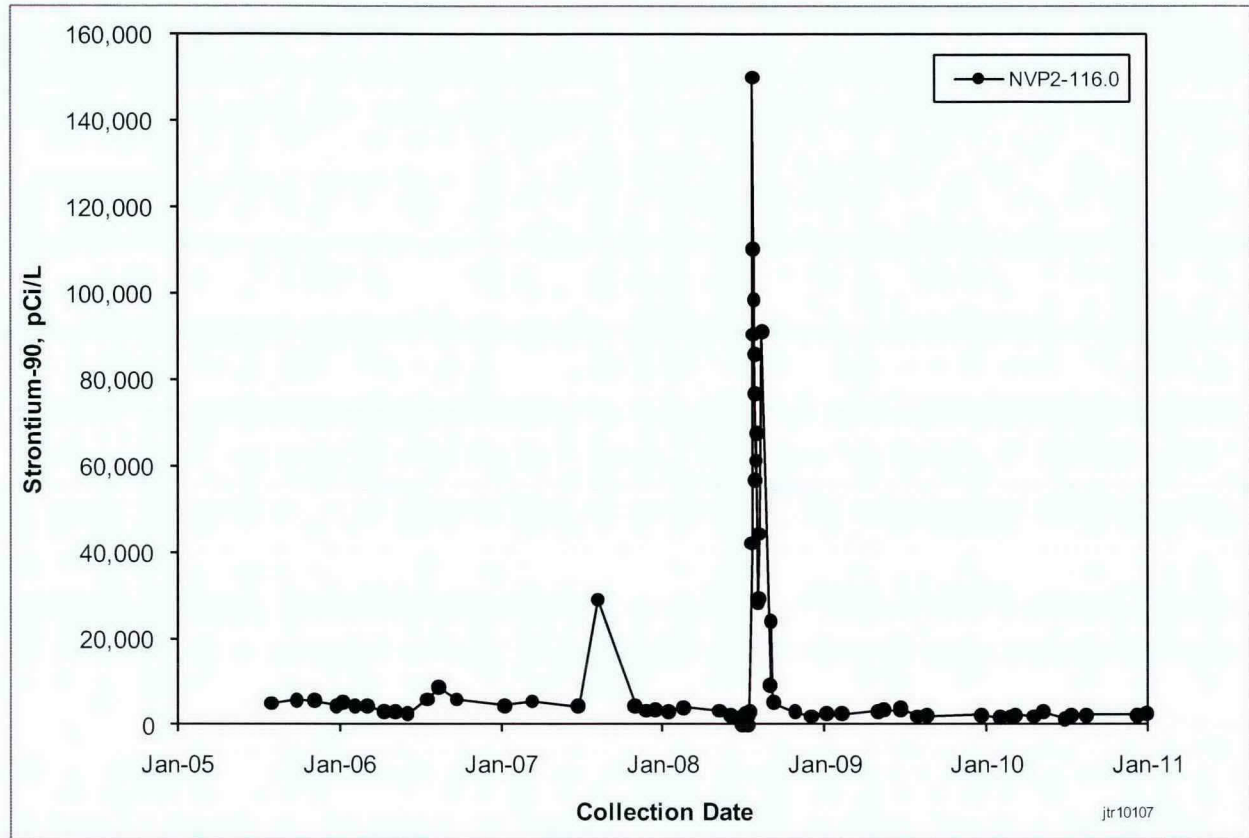


Figure 4-13. Strontium-90 Trend Plot for Aquifer Tube NVP2-116.0m, Apatite PRB

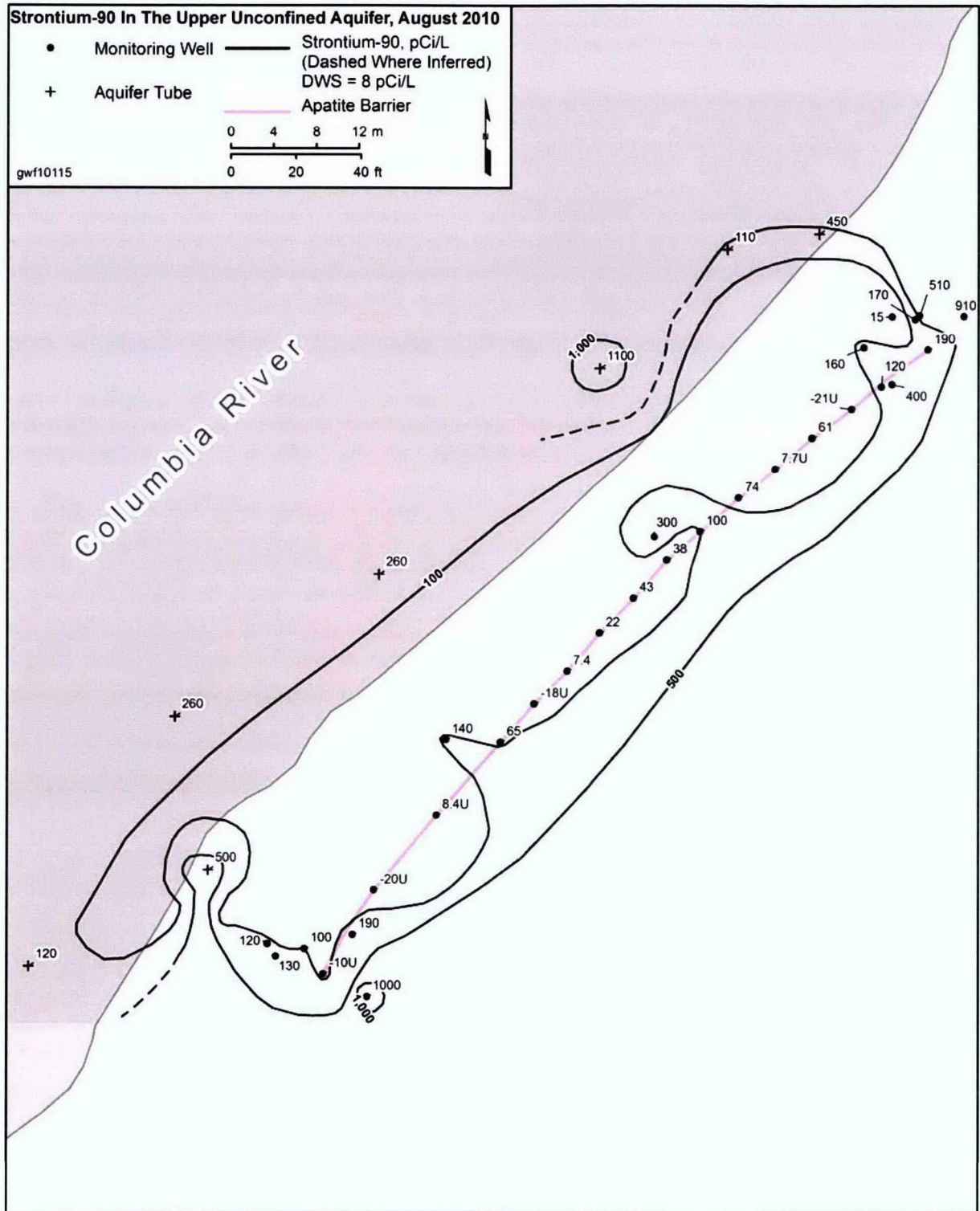


Figure 4-14. Strontium-90 Plume Map for 100-N Area

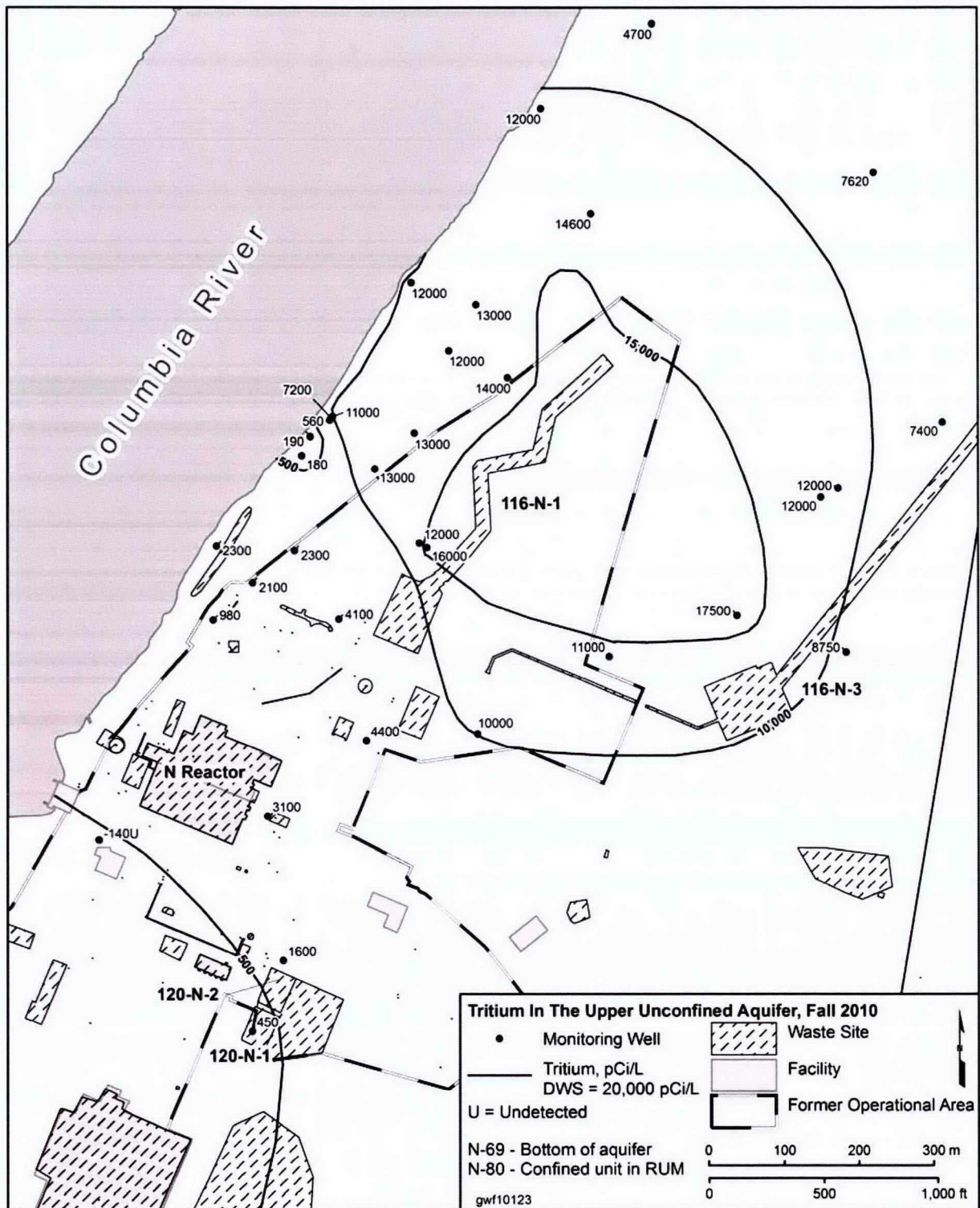


Figure 4-15. Tritium Plume Map for 100-N Area

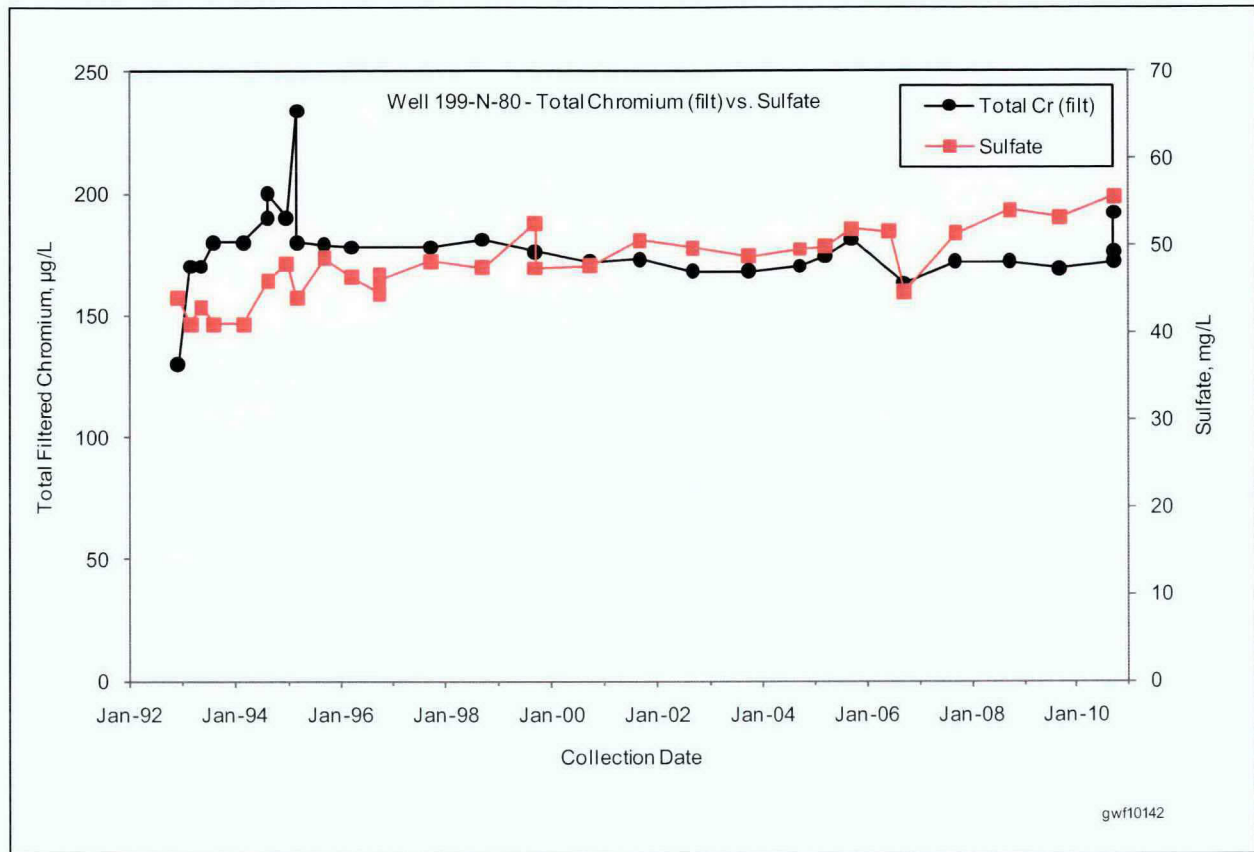
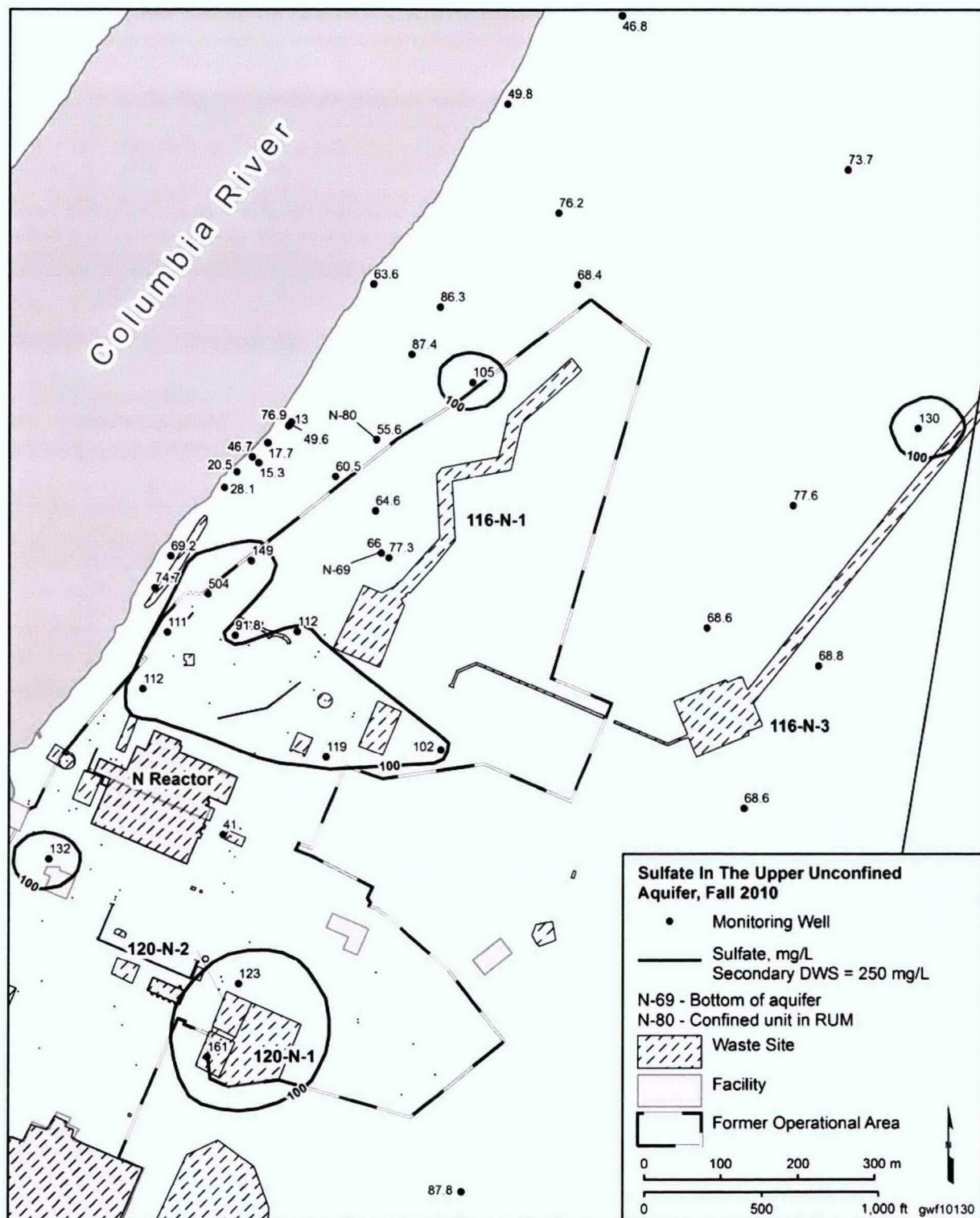


Figure 4-16. Filtered Total Chromium and Sulfate Trend Plot for Well 199-N-80





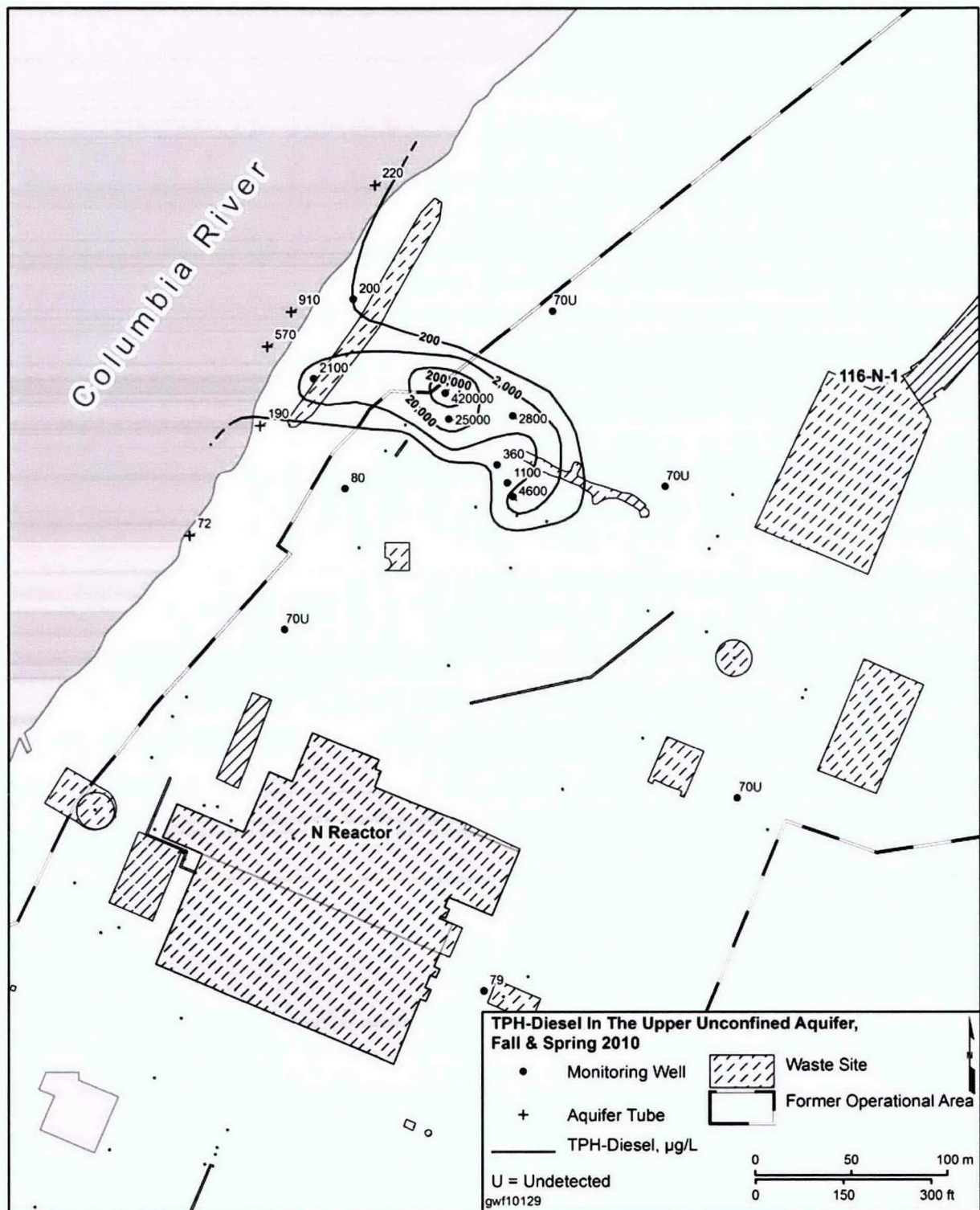


Figure 4-19. TPH-Diesel Plume Map for 100-N Area

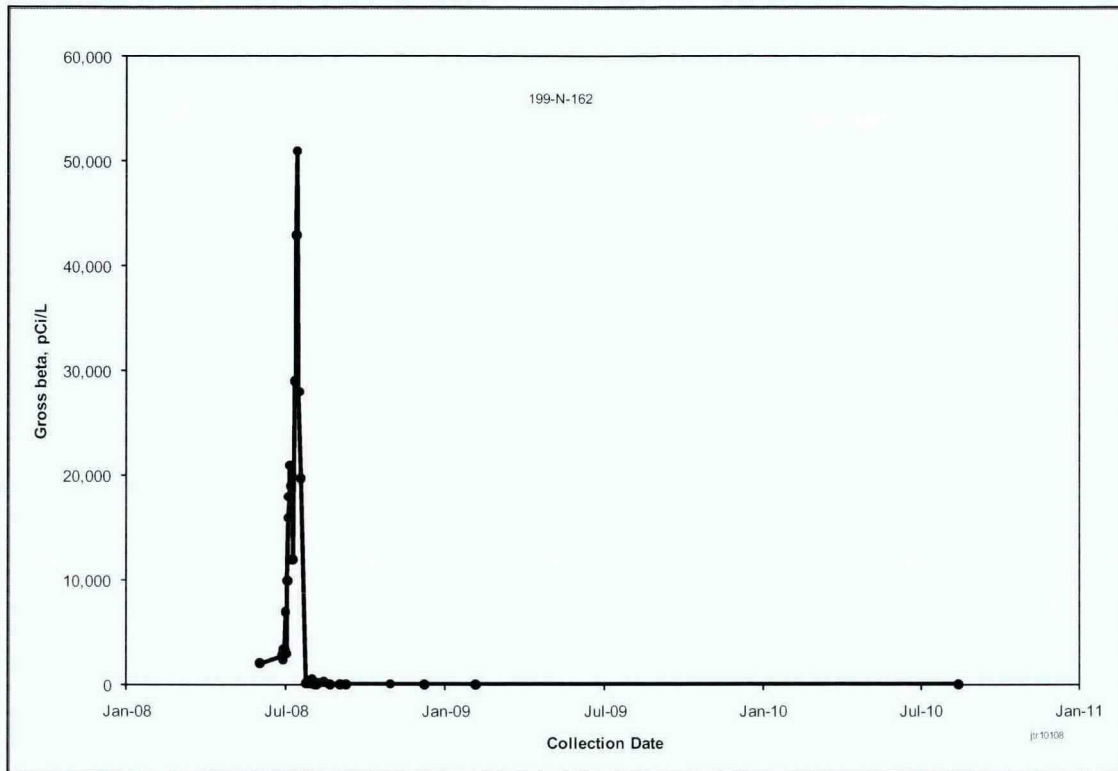


Figure 4-20. Gross Beta Concentration in Well 199-N-162

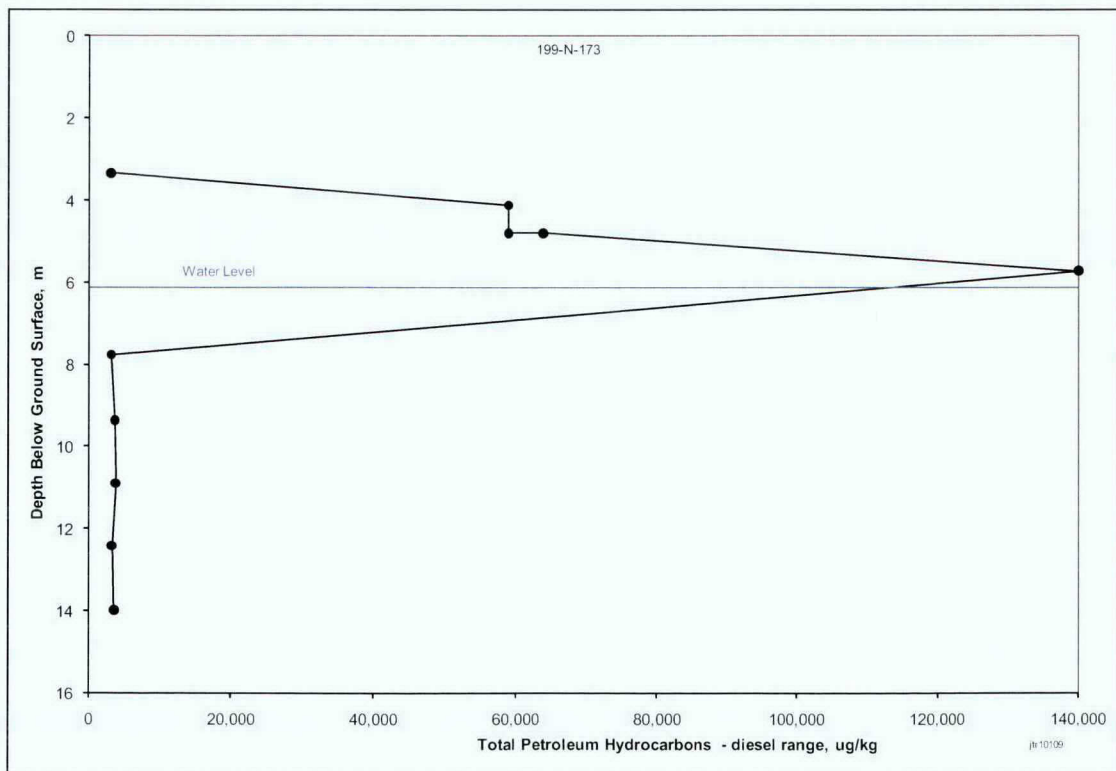


Figure 4-21. TPH Soil Concentration with Depth

**Table 4-1. Yearly Average River Elevations,  
100-N Area River Gauge Station**

<b>Year</b>	<b>Average River Elevation</b>	<b>Percent Difference from Previous Year</b>
2010	117.76 m (386.35 ft)	0.28%
2009	118.09 m (387.43 ft)	0.09%
2008	118.20 m (387.47 ft)	0.03%
2007	118.24 m (387.93 ft)	0.14%
2006	118.41 m (387.47 ft)	0.17%
2005	118.21 m (387.83 ft)	---

**Table 4-2. Well Water-Level Response to Changes in River Stage**

<b>N River Gauge</b>		<b>199-N-99A</b>		<b>199-N-14</b>		<b>199-N-50</b>	
<b>Date</b>	<b>Elevation (m)</b>	<b>Date</b>	<b>Elevation (m)</b>	<b>Date</b>	<b>Elevation (m)</b>	<b>Date</b>	<b>Elevation (m)</b>
<b>Spring Low</b>							
4/11/10	117.03	4/15/10	117.16	4/18/10	117.46	4/20/10	117.55
<b>Late Spring/Early Summer High</b>							
6/22/10	120.19	6/24/10	120.23	7/1/10	119.41	6/30/10	119.48
<b>Fall Low</b>							
9/25/10	116.94	9/27/10	117.00	10/2/10	117.74	10/4/10	117.65

Table 4-3. Strontium-90 Concentrations in Monitoring Wells and Aquifer Tubes

Well/Tube Name	Before P&T, Fall 1994 (pCi/L)	During P&T, Fall 2005 (pCi/L)	P&T in Cold-Standby Status, 2008 (pCi/L)	P&T in Cold-Standby Status, 2009 (pCi/L)	P&T in Cold-Standby Status, 2010 (pCi/L)	% Change 1994 to 2010	% Change 2005 to 2010
199-N-2	121	80.7	1,100	160	--	32% <sup>a</sup>	98% <sup>a</sup>
199-N-3	927	1,330	1,200	1,060	870	-6%	-35%
199-N-14	1,210	1,070	1,300	1,360	1,400	16%	31%
199-N-16	0.34	-0.08 (U)	0.06 (U)	-0.04 (U)	-2.70 (U)	NC	NC
199-N-18	392	--	290	-12 (U)	260	-34%	-10%
199-N-19	43.6	28.2	--	--	23	-47%	-18%
199-N-21	1.50	--	--	-2.60 (U)	-7.6 (U)	NC	NC
199-N-26	0.14 (U)	0.09 (U)	--	--	3.35 <sup>b</sup>	NC	NC
199-N-27	171	167	160	130	125	-27%	-25%
199-N-28	120	25.1	21	25	20	-83%	-20%
199-N-32	1.27	0.358 (U)	-1.40 (U)	-1.60 (U)	-4.8 (U)	NC	NC
199-N-34	69.3	53.5	67	44	37	-47%	-31%
199-N-41	0.004 (U)	-0.10 (U)	-0.41 (U)	-1.20 (U)	-1.80 (U)	NC	NC
199-N-46	5,850	2,690	630	580	530	-91%	-80%
199-N-50	-0.02 (U)	--	--	--	-0.20 (U)	NC	NC
199-N-51	0.254 (U)	0.05 (U)	--	--	-5.30 (U)	NC	NC
199-N-56	--	317	170	140	-7.5 (U)	--	-102%
199-N-57	26	9.71	8.51	2.90	5.80	-78%	-40%
199-N-64	0.185 (U)	0.785 (U)	0.256 (U)	-5.30 (U)	-4.60 (U)	NC	NC
199-N-67	3,680	9,710	10,000	9,000	9,800	166%	1%

Table 4-3. Strontium-90 Concentrations in Monitoring Wells and Aquifer Tubes

Well/Tube Name	Before P&T, Fall 1994 (pCi/L)	During P&T, Fall 2005 (pCi/L)	P&T in Cold-Standby Status, 2008 (pCi/L)	P&T in Cold-Standby Status, 2009 (pCi/L)	P&T in Cold-Standby Status, 2010 (pCi/L)	% Change 1994 to 2010	% Change 2005 to 2010
199-N-69 <sup>c</sup>	-0.09 (U)	0.21 (U)	--	--	-3.20 (U)	NC	NC
199-N-70 <sup>c</sup>	0.321 (U)	0.156 (U)	-2.60 (U)	-2.40 (U)	-3.80 (U)	NC	NC
100-N-71	0.55	--	0.38 (U)	-0.05 (U)	-2.80 (U)	NC	NC
199-N-72	2.59 <sup>b</sup>	--	-1.00 (U)	--	-1.70 (U)	NC	NC
199-N-74	0.415	-0.08 (U)	2.3 <sup>b</sup>	405 <sup>b</sup>	-2.0 (U)	NC	NC
199-N-75 <sup>d</sup>	2,110	307	2,500	3,000	2,400	14%	682%
199-N-76	84.9	216	180	180	120	41%	-44%
199-N-80 <sup>c</sup>	0.734 (Q)	-0.154 (U)	0.82 (U)	-0.07 (U)	-5.9 (U)	NC	NC
199-N-81	746	734	970	400	320	-57%	-56%
199-N-92A	0.59 (U)	0.92	1.22	3.50	-9 (U)	NC	NC
199-N-96A	4.90 <sup>c</sup>	5.74	1.65	-1.30 (U)	3.94	-20%	-31%
199-N-99A	2,860 <sup>c</sup>	1,270	1,200	1,400	1,500	-48%	18%
199-N-103A <sup>d</sup>	4.08 <sup>c</sup>	422	1,200	1,200	1,400	34,214%	232%
199-N-105A <sup>d</sup>	112 <sup>c</sup>	1,360	1,900	1,500	1,600	1,329%	18%
199-N-106A <sup>d</sup>	2,890 <sup>c</sup>	3,260	2,200	1,800	--	-38% <sup>a</sup>	-45% <sup>a</sup>
199-N-119	--	280	250	210	220	--	-21%
199-N-120 <sup>c</sup>	--	10.1	6.55	--	1.40 (U)	--	-86%
199-N-121 <sup>c</sup>	--	0.272 (U)	0.0169 (U)	--	-2.00 (U)	--	-835%
199-N-122	--	730	1,160	260	800	--	10%
199-N-123	--	871	255	-1.60 (U)	280	--	-68%

Table 4-3. Strontium-90 Concentrations in Monitoring Wells and Aquifer Tubes

Well/Tube Name	Before P&T, Fall 1994 (pCi/L)	During P&T, Fall 2005 (pCi/L)	P&T in Cold-Standby Status, 2008 (pCi/L)	P&T in Cold-Standby Status, 2009 (pCi/L)	P&T in Cold-Standby Status, 2010 (pCi/L)	% Change 1994 to 2010	% Change 2005 to 2010
199-N-146	--	318 <sup>f</sup>	412	260	300	--	-6%
199-N-147	--	522 <sup>f</sup>	791	250	250	--	-52%
199-N-165	--	--	--	-1.90 (U)	-6.60 (U)	--	--
199-N-173	--	--	--	16	23	--	--
116m Array 3A	--	379	1,750 <sup>b</sup>	500	110	--	-71%
116m Array 4A	--	1,260	7,000 <sup>b</sup>	340	270	--	-79%
116m Array 6A	--	477	370 <sup>b</sup>	95 <sup>b</sup>	110	--	-77%
NVP2-116.0	--	3,200	2,550 <sup>b</sup>	1,100	1,200	--	-63%

Notes:

1. Data from the fall of the year, unless otherwise noted.
  2. Yellow-shaded cells show wells with concentrations above the DWS (8 pCi/L). Pink-shaded cells indicate increases in concentration since before P&T operations started and/or after P&T operations ceased.
    - a. Calculated from 2009 value, not sampled in 2010.
    - b. Value calculated from gross beta data (strontium-90 data not available); value listed is one-half gross beta value measured.
    - c. Screened at depth in Ringold Formation.
    - d. Former P&T extraction well.
    - e. Not sampled in 1994; value from 1995 used for table.
    - f. Not sampled in 2005; value from 2006 used for table.
- NC = not calculated because concentrations are too low or both numbers are nondetects  
 Q = associated with out-of-limits quality control samples  
 U = nondetect

Table 4-4. Tritium Concentrations in Monitoring Wells and Aquifer Tubes

Well/Tube Name	Before P&T, Fall 1994 (pCi/L)	During P&T, Fall 2005 (pCi/L)	P&T in Cold-Standby Status, 2008 (pCi/L)	P&T in Cold-Standby Status, 2009 (pCi/L)	P&T in Cold-Standby Status, 2010 (pCi/L)	% Change 1994 to 2010	% Change 2005 to 2010
199-N-2	27,500	21,500	16,000	17,000	--	-38%	-21% <sup>a</sup>
199-N-3	20,800	3,790	2,000	2,200	2,300	-89%	-39%
199-N-14	63,100	20,400	16,000	15,300	14,600	-77%	-28%
199-N-16	259 (U)	300	--	--	3,100	1,097%	933%
199-N-18	5,710 <sup>b</sup>	--	--	--	2,100	-63%	NC
199-N-19	2,340	--	--	--	980	-58%	NC
199-N-21	940	--	--	--	--	NC	NC
199-N-26	398	122 <sup>c</sup>	--	--	-140 (U)	-135%	-215%
199-N-27	28,600	20,300	12,000	10,000	8,750	-69%	-57%
199-N-28	35,900	15,400	15,000 <sup>d</sup>	--	--	NC	NC
199-N-32	65,400	26,300	19,000	20,000	17,500	-73%	-33%
199-N-34	24,000	14,900	11,000	13,000	11,000	-54%	-26%
199-N-41	23,000	9,980	8,700	8,200	7,400	-68%	-26%
199-N-46	19,900 <sup>b</sup>	449	120 (U)	75 (U)	180	-99%	-60%
199-N-50	26,700	9,920	8,200	8,220	7,620	-71%	-23%
199-N-51	27,200	10,100	5,600	6,400	4,700	-83%	-53%
199-N-56	--	4,800 <sup>c</sup>	--	3,200	4,100	NC	-15%
199-N-57	5,000	--	--	5,500	4,400	-12%	NC
199-N-64	16,600	14,200	12,000	1,000	10,000	-40%	-30%
199-N-67	29,500	28,100	12,000	--	16,000	-46%	-43%

Table 4-4. Tritium Concentrations in Monitoring Wells and Aquifer Tubes

Well/Tube Name	Before P&T, Fall 1994 (pCi/L)	During P&T, Fall 2005 (pCi/L)	P&T in Cold-Standby Status, 2008 (pCi/L)	P&T in Cold-Standby Status, 2009 (pCi/L)	P&T in Cold-Standby Status, 2010 (pCi/L)	% Change 1994 to 2010	% Change 2005 to 2010
199-N-69 <sup>e</sup>	31,900	15,400	--	--	12,000	-62%	-22%
199-N-70 <sup>e</sup>	36,300	17,300	14,000	14,000	12,000	-67%	-31%
100-N-71	465	--	8,800	1,120	1,000	115%	-89% <sup>f</sup>
199-N-72	--	--	1,800	--	1,600	NC	NC
199-N-74	18,000	5,450	--	--	7,200	-60%	32%
199-N-75 <sup>g</sup>	73,100	13,900	14,000	14,000	12,000	-84%	-14%
199-N-76	58,900	22,300	14,000	14,000	13,000	-78%	-42%
199-N-80 <sup>e</sup>	45,200	20,800	15,000	16,000	13,000	-71%	-38%
199-N-81	37,000	18,800	14,000	14,000	12,000	-68%	-36%
199-N-92A	46,000 <sup>b</sup>	10,400	10,000	13,000	12,000	-74%	-15%
199-N-96A	5,900 <sup>b</sup>	2,860	2,630	3,000	2,300	-61%	-20%
199-N-99A	42,100 <sup>b</sup>	-29.70 (U)	5,900	12,100	12,000	-71%	40,504%
199-N-103A <sup>g</sup>	--	14,700	12,000	14,000	13,000	NC	-12%
199-N-105A <sup>g</sup>	23,800 <sup>b</sup>	21,600	15,000	15,000	14,000	-41%	-35%
199-N-106A <sup>g</sup>	--	21,100	14,000	15,000	--	NC	-29%
199-N-119	--	70.70 (U)	320	240	560	NC	692%
199-N-120 <sup>e</sup>	--	165 (U)	2,400	--	7,200	NC	4,264%
199-N-121 <sup>e</sup>	--	1,140	4,400	--	11,000	NC	865%
199-N-122	--	148 (U)	-43 (U)	--	--	NC	NC
199-N-123	--	166 (U)	310	--	--	NC	NC

Table 4-4. Tritium Concentrations in Monitoring Wells and Aquifer Tubes

Well/Tube Name	Before P&T, Fall 1994 (pCi/L)	During P&T, Fall 2005 (pCi/L)	P&T in Cold-Standby Status, 2008 (pCi/L)	P&T in Cold-Standby Status, 2009 (pCi/L)	P&T in Cold-Standby Status, 2010 (pCi/L)	% Change 1994 to 2010	% Change 2005 to 2010
199-N-146	--	--	68 (U)	--	--	NC	NC
199-N-147	--	--	-64 (U)	--	230	NC	NC
199-N-165	--	--	--	620	450	NC	NC
199-N-173	--	--	--	2,900	--	NC	NC
116m Array 3A	--	--	25 (U)	-130 (U)	--	NC	NC
116m Array 4A	--	--	14 (U)	--	--	NC	NC
116m Array 6A	--	--	-10 (U)	--	--	NC	NC
NVP2-116.0	--	64.8 (U)	7.70 (U)	160 (U)	--	NC	NC

## Notes:

1. Data from the fall of the year unless otherwise noted.
  2. Yellow-shaded cells show wells with concentrations above the DWS (20,000 pCi/L). Pink-shaded cells indicate increases in concentration since before P&T operations started and/or after P&T operations ceased.
    - a. Calculated from 2009 value; not sampled in 2010.
    - b. Not sampled in 1994; value from 1995 used for table.
    - c. Not sampled in 2005; value from 2006 used for table.
    - d. Not sampled in 2008; value from 2007 used for table.
    - e. Screened at depth in Ringold Formation.
    - f. Calculated percent change from 2008 to 2010.
    - g. Former P&T extraction well.
- NC = not calculated because concentrations are too low or both numbers are nondetect  
 U = nondetect

Table 4-5. Total Chromium Concentrations in Monitoring Wells and Aquifer Tubes

Well/Tube Name	Before P&T, Fall 1994 (µg/L)	During P&T, Fall 2005 (µg/L)	P&T in Cold-Standby Status, 2008 (µg/L)	P&T in Cold-Standby Status, 2009 (µg/L)	P&T in Cold-Standby Status, 2010 (µg/L)	% Change 1994 to 2010	% Change 2005 to 2010
199-N-2	11 (U)	3.4 (B)	3.1 (B)	13 (U)	14 (U)	NC	NC
199-N-3	11 (U)	4.6 (B)	3.1 (U)	13 (U)	14 (U)	NC	NC
199-N-14	11 (U)	6.7 (B)	3.3 (B)	13 (U)	3.4 (B)	NC	NC
199-N-16	11 (U)	6.7 (B)	3.7 (B)	13 (U)	14 (U)	NC	NC
199-N-18	--	3.3 (U)	3.1 (U)	3.1 (U)	127	NC	3,748%
199-N-19	--	--	--	--	3.63 (B,D,C)	NC	NC
199-N-21	11 (L)	3.3 (U)	--	13 (U)	14 (U)	NC	NC
199-N-26	11 (U)	4.3 (B)	--	--	14 (U)	NC	NC
199-N-27	15 (L)	5.2 (B)	11.9	15.1 (B)	14 (U)	NC	NC
199-N-28	5.0 (L)	3.3 (B)	4.1 (B)	13 (U)	14 (U)	NC	NC
199-N-32	11 (U)	2.9 (B)	3.1 (U)	13 (U)	3.1 (U)	NC	NC
199-N-34	11 (U)	3.3 (U)	3.4 (B)	13 (U)	14 (U)	NC	NC
199-N-41	11 (U)	13.4	13 (U)	13 (U)	13 (U)	NC	NC
199-N-46	--	3.0 (B)	13 (U)	13 (U)	13 (U)	NC	NC
199-N-50	11 (U)	12.9	--	--	12.9(D)	NC	NC
199-N-51	14 (L)	--	--	--	12.6 (D)	NC	NC
199-N-56	--	--	--	13 (U)	14 (U)	NC	NC
199-N-57	11 (U)	8.3 (B)	4.0 (U)	13 (U)	14 (U)	NC	NC
199-N-64	77	56.4 (G)	12.1 (C)	13 (U)	14 (U)	NC	NC
199-N-67	11 (U)	4.7 (B)	6.9 (B)	13 (U)	5.9 (B,D)	NC	NC

Table 4-5. Total Chromium Concentrations in Monitoring Wells and Aquifer Tubes

Well/Tube Name	Before P&T, Fall 1994 (µg/L)	During P&T, Fall 2005 (µg/L)	P&T in Cold-Standby Status, 2008 (µg/L)	P&T in Cold-Standby Status, 2009 (µg/L)	P&T in Cold-Standby Status, 2010 (µg/L)	% Change 1994 to 2010	% Change 2005 to 2010
199-N-69	11 (U)	--	--	--	4.03 (B,D)	NC	NC
199-N-70 <sup>a</sup>	11 (U)	11.2	7.9 (B)	13 (U)	14 (U)	NC	NC
199-N-71	11 (U)	9.4 (B)	4.0 (U)	3.1 (U)	5.42 (B)	NC	NC
199-N-72	11 (U)	4.4 (B)	6.4	13 (U)	8.02 (B,D,C)	NC	NC
199-N-74	16 (LQ)	13.8 (C)	24	28 (B)	31 (D)	NC	NC
199-N-75 <sup>b</sup>	11 (U)	2.4 (B)	3.1 (U)	13 (U)	14 (U)	NC	NC
199-N-76	11 (U)	7.4 (B)	4.0 (B)	13 (U)	14 (U)	NC	NC
199-N-80 <sup>a</sup>	190	181	172	169	192	1%	6%
199-N-81	11 (U)	7.5 (B)	4.8 (B)	13 (U)	14 (U)	NC	NC
199-N-92A	--	9.6 (B)	14.5 (B)	13 (U)	14 (U)	NC	NC
199-N-96A	--	3.1 (U)	3.1 (U)	13 (U)	14 (U)	NC	NC
199-N-99A	--	2.6 (B)	3.1 (U)	13 (U)	14 (U)	NC	NC
199-N-103A <sup>b</sup>	--	4.9 (B)	3.1 (U)	13 (U)	14 (U)	NC	NC
199-N-105A <sup>b</sup>	--	3.4 (B)	3.1 (U)	13 (U)	14 (U)	NC	NC
199-N-106A <sup>b</sup>	--	3.4 (B)	3.8 (B)	13 (U)	--	NC	NC
199-N-119	--	1.90 (U)	3.1 (U)	13 (U)	14 (U)	NC	NC
199-N-120 <sup>a</sup>	--	1.90 (U)	--	4 (U)	14 (U)	NC	NC
199-N-121 <sup>a</sup>	--	1.90 (U)	--	4 (U)	14 (U)	NC	NC
199-N-122	--	1.90 (U)	65 (U)	13 (U)	14 (U)	NC	NC
199-N-123	--	1.90 (U)	65 (U)	13 (U)	14 (U)	NC	NC

Table 4-5. Total Chromium Concentrations in Monitoring Wells and Aquifer Tubes

Well/Tube Name	Before P&T, Fall 1994 (µg/L)	During P&T, Fall 2005 (µg/L)	P&T in Cold-Standby Status, 2008 (µg/L)	P&T in Cold-Standby Status, 2009 (µg/L)	P&T in Cold-Standby Status, 2010 (µg/L)	% Change 1994 to 2010	% Change 2005 to 2010
199-N-146	--	3.10 (U)	65 (U)	13 (U)	14 (U)	NC	NC
199-N-147	--	3.10 (U)	65 (U)	13 (U)	14 (U)	NC	NC
199-N-165	--	--	--	13 (U)	14 (U)	NC	NC
199-N-173	--	--	--	13 (U)	14 (U)	NC	NC
116m Array 3A	--	0.88 (X)	65 (U)	13 (U)	14 (U)	NC	NC
116m Array 4A	--	2.52 (X)	65 (U)	13 (U)	14 (U)	NC	NC
116m Array 6A	--	0.95 (X)	65 (U)	13 (U)	14 (U)	NC	NC
NVP2-116.0	--	1.09 (X)	13 (U)	13 (U)	14 (U)	NC	NC

## Notes:

1. Data from the fall of the year, unless otherwise noted.
  2. Yellow-shaded cells indicate a value above the detection limit. Orange-shaded cells show wells with concentrations above the DWS (100 µg/L). Pink-shaded cells indicate increases in concentration since before P&T operations started and/or after P&T operations ceased.
    - a. Screened at depth in Ringold Formation.
    - b. Former P&T extraction well.
- B = analyte was detected at a value less than RDL but greater than IDL/MDL  
 C = contaminant detected in quality control blank associated with sample  
 D = diluted  
 G = result has been reviewed and determined to be correct  
 NC = not calculated because concentrations are too low or both numbers are nondetect  
 L = MDL less than or equal to value, less than contract-required detection limit (retired, only found on older samples)  
 Q = result associated with suspect quality control data  
 U = nondetect  
 X = explanation can only be found in the hardcopy data report

Table 4-6. Chromium and Hexavalent Chromium Results for Well 199-N-80, 2006 and 2010

Date	Total Chromium, Unfiltered (µg/L)	Total Chromium, Filtered (µg/L)	Hexavalent Chromium, Unfiltered (µg/L)	RPD (Total Chromium, Filtered and Hexavalent Chromium, Unfiltered)
6/7/06	179.00	163.00	175.00	7.1%
9/20/10*	182.00	172.00	177.00	2.9%
9/20/10*	175.00	192.00	188.00	2.1%
9/20/10*	186.00	176.00	189.00	7.1%

\* The samples collected on 9/20/10 were collected during the same sample event, after purging three borehole volumes, four borehole volumes, and at the end sampling.

Table 4-7. Well 199-N-74 Chromium Detections During 2010 Sampling

Date	Total Chromium, Unfiltered (µg/L) Method 200.8/6010	Total Chromium, Filtered (µg/L) Method 200.8/6010	Hexavalent Chromium, Unfiltered (µg/L) <sup>a</sup> Method 7196	RPD (Chromium, Filtered, Hexavalent Chromium Unfiltered) Method 200.8/6010/7196 <sup>b</sup>	
6/22/10	32.00/ 28.00 (B)	32.50 (B)/ 25.00 (B)	26.50 26.70	19.97% 6.20%	0.75%
9/19/10	36.70 (D)/ 30.00 (B)	31.00 (D)/ 27.00 (B)	25.90 27.40	15.09% 1.30%	5.63%

a. Duplicate samples collected.

b. RPD calculated for Method 200.8 (top number) and Method 6010 (bottom number).

Table 4-8. Nitrate Concentrations in Monitoring Wells and Aquifer Tubes

Well/Tube Name	Before P&T, Fall 1994 (mg/L)	During P&T, Fall 2005 (mg/L)	P&T in Cold-Standby Status, 2008 (mg/L)	P&T in Cold-Standby Status, 2009 (mg/L)	P&T in Cold-Standby Status, 2010 (mg/L)	% Change 1994 to 2010	% Change 2005 to 2010
199-N-2	35 (D)	64.2 (D)	97.4 (D)	166 (D)	224 (D)	540%	249%
199-N-3	49 (D)	79.2 (D)	80.1 (D)	107 (D)	94.3 (D)	92%	19%
199-N-14	13 (D)	26.1 (D)	49.1 (D)	49.1 (D)	50 (D)	285%	92%
199-N-16	27 (D)	3.01	5.87 (H)	0.398 (B,D)	0.096 (B,D)	-100%	-97%
199-N-18	--	0.018 (U)	0.089 (U,D)	1.37 (U,D)	2.17 (U,D)	NC	NC
199-N-19	45 (D)	--	--	--	89.4 (D)	99%	NC
199-N-21	32 (D)	51.8 (D)	--	68.2 (D)	64.6 (D)	102%	25%
199-N-26	63 (D)	62.4 (D)	--	--	50.5 (D)	-20%	-19%
199-N-27	19 (D)	35.0 (D)	27.3 (D)	24.6 (D)	25.2 (D)	33%	-28%
199-N-28	12 (D)	39.0 (D)	40.7 (D)	45.6 (D)	52.2 (D)	335%	34%
199-N-32	43 (D)	68.6 (D,N)	69.7 (D,H)	71.7 (D)	70.8 (D)	653%	3%
199-N-34	15 (D)	43.8 (D)	98 (D,H)	51.4 (D)	---	243% <sup>a</sup>	17% <sup>a</sup>
199-N-41	12 (D)	26.1 (D)	29.5 (D,Q)	30.0 (D)	30.1 (D)	151%	15%
199-N-46	--	3.85	17.6 (D)	46.9 (D)	6.51 (D)	NC	69%
199-N-50	13 (D)	25.7 (D)	--	--	26.3 (D)	102%	2%
199-N-51	16 (D)	--	--	--	19.5 (D)	22%	NC
199-N-56	--	46.0 (D) <sup>d</sup>	44.3 (D)	51.4 (D)	51.4 (D)	NC	12%
199-N-57	16 (D)	50.0 (D)	58.0 (D,H)	57.5 (D)	60.6 (D)	279%	21%
199-N-64	25 (D)	78.3 (D)	57.1 (D)	59.8 (D)	44.7 (D)	79%	-43%

Table 4-8. Nitrate Concentrations in Monitoring Wells and Aquifer Tubes

Well/Tube Name	Before P&T, Fall 1994 (mg/L)	During P&T, Fall 2005 (mg/L)	P&T in Cold-Standby Status, 2008 (mg/L)	P&T in Cold-Standby Status, 2009 (mg/L)	P&T in Cold-Standby Status, 2010 (mg/L)	% Change 1994 to 2010	% Change 2005 to 2010
199-N-67	26 (D)	238(D)	220 (D)	383 (D)	500 (D)	1,823%	110%
199-N-69 <sup>b</sup>	10 (D)	--	--	--	61.1 (D)	511%	NC
199-N-70 <sup>b</sup>	18 (D)	22.1 (D)	30.7 (D,Q)	30.8 (D)	--	71% <sup>a</sup>	39% <sup>a</sup>
100-N-71	1.8	8.85 (D)	10.8 (D)	12.4 (D)	12.8 (D)	611%	45%
199-N-72	2.0	54.9 (D)	63.7 (D)	58.9 (D)	38.4 (D)	1,820%	-30%
199-N-74	8.9	10.2 (D)	14.4 (D)	15.3 (D)	16.9 (D)	90%	66%
199-N-75 <sup>c</sup>	8.9 (D)	31.9 (D)	58.9 (D)	73.9 (D)	49.6 (D)	457%	55%
199-N-76	8.2	58.0 (D,H)	59.3 (D)	66.8 (D)	66.4 (D)	710%	14%
199-N-80 <sup>b</sup>	9.5 (D)	10.2 (D)	9.92 (D)	9.83 (D)	10.7 (D)	13%	5%
199-N-81	23 (D)	35.4 (D)	41.3 (D)	42.7 (D)	41.5 (D)	80%	17%
199-N-92A	--	17.7 (D)	19.8 (D)	21.4 (D)	24.7 (D)	NC	40%
199-N-96A	--	30.5 (D)	19.7 (D)	14.3 (D)	15.6 (D)	NC	-49%
199-N-99A	--	6.2 (D)	19.5(D)	34.5 (D)	47.8 (D)	NC	671%
199-N-103A <sup>c</sup>	--	41.6 (D)	37.5 (D)	49.6 (D)	73.9 (D)	NC	78%
199-N-105A <sup>c</sup>	--	81.9 (D)	102 (D)	128 (D)	109 (D)	NC	33%
199-N-106A <sup>c</sup>	--	39.8 (D)	43.2 (D)	41.9 (D)	--	NC	5% <sup>a</sup>
199-N-119	--	1.99	4.20 (D)	3.81 (D)	5.84 (D)	NC	193%
199-N-120 <sup>b</sup>	--	3.54	28.7 (D)	--	32.4 (D)	NC	814%
199-N-121 <sup>b</sup>	--	7.53 (D)	41.7 (D)	--	45.2 (D)	NC	500%
199-N-122	--	0.841	72.6 (D)	8.41(D,X)	23.9 (D)	NC	2,742%

Table 4-8. Nitrate Concentrations in Monitoring Wells and Aquifer Tubes

Well/Tube Name	Before P&T, Fall 1994 (mg/L)	During P&T, Fall 2005 (mg/L)	P&T in Cold-Standby Status, 2008 (mg/L)	P&T in Cold-Standby Status, 2009 (mg/L)	P&T in Cold-Standby Status, 2010 (mg/L)	% Change 1994 to 2010	% Change 2005 to 2010
199-N-123	--	2.92	25.0 (U,D)	17.4 (D)	35.6 (D)	NC	1,139%
199-N-146	--	1.90 (N) <sup>d</sup>	0.536 (D)	10.7 (D)	32.4 (D)	NC	1,605%
199-N-147	--	1.24 (N)	25.0 (D)	12.0 (D,X)	39.1 (D)	NC	3,053%
199-N-165	--	--	--	39.5 (D)	40.6 (D)	NC	NC
199-N-173	--	--	--	16.7 (D)	16.4 (D)	NC	NC
116m Array 3A	--	5.67	0.536 (U,D)	0.274 (U,D)	0.084 (U,D)	NC	-99%
116m Array 4A	--	3.34	25.0 (U,D)	2.36 (D)	2.74 (D)	NC	-18%
116m Array 6A	--	2.30	25.0 (U,D)	3.37 (B,D)	6.46 (D)	NC	181%
NVP2-116.0	--	7.83	25.0 (U,D)	1.62 (D)	3.43 (D)	NC	-56%

## Notes:

1. Data from the fall of the year unless otherwise noted.
  2. Orange-shaded cells show values above the DWS (45 µg/L). Yellow-shaded cells show wells with values above the detection limit(s). Pink-shaded cells indicate increases in concentration since before P&T operations started and/or after P&T operations ceased.
    - a. Calculated percent change from 1994 to 2009 and 2005 to 2009 because no samples were collected in 2010.
    - b. Screened at depth in Ringold Formation.
    - c. Former P&T extraction well.
    - d. Not sampled in 2005; value from 2006 used for table.
- B = analyte was detected at a value <RDL, but >IDL/MDL  
 D = sample was diluted for analysis  
 H = holding time exceeded before sample analyzed  
 N = spike sample outside limits  
 NC = not calculated because concentrations are too low or both numbers are nondetects  
 Q = associated with out-of-limits quality control data  
 U = undetected  
 X = explanation can only be found in the hard copy data report

Table 4-9. Sulfate Concentrations in Monitoring Wells and Aquifer Tubes

Well/Tube Name	Before P&T, Fall 1994 (pCi/L)	During P&T, Fall 2005 (pCi/L)	P&T in Cold-Standby Status, 2008	P&T in Cold-Standby Status, 2009	P&T in Cold-Standby Status, 2010	% Change 1994 to 2010	% Change 2005 to 2010
199-N-2	18 (D)	52.9 (D)	63.1 (D)	62.2 (D)	64.6 (D)	259%	22%
199-N-3	140 (D)	182 (D)	152 (D)	155 (D)	149 (D)	6%	-18%
199-N-14	15 (D)	37.7 (D)	77.1 (D)	73.8 (D)	76.2 (D)	408%	102%
199-N-16	160 (D)	51.4 (D)	48.0 (D)	42.9 (D)	41.0 (D)	-74%	-20%
199-N-18	--	0.61 (N,Q)	0.3 (U,D)	0.265 (B,D)	504 (D)	NC	82,523%
199-N-19	250 (D)	--	--	--	111 (D)	-56%	NC
199-N-21	350 (D)	97 (D)	--	118(D)	112 (D)	-68%	15%
199-N-26	180 (D)	96.6 (D)	--	--	132 (D)	-27%	37%
199-N-27	86 (D)	65.6 (D)	69.7 (D)	69.3 (D)	68.8 (D)	-20%	5%
199-N-28	23 (D)	58.2 (,CD,N)	70.9 (D)	64.2 (D)	68.6 (D)	198%	18%
199-N-32	21 (D)	58.0 (D,N)	70.2 (D)	64.9 (D)	68.6 (D)	227%	18%
199-N-34	89 (D)	70.6 (C,D,N)	129 (D)	82.2 (D)	--	-8% <sup>a</sup>	16% <sup>a</sup>
199-N-41	28 (D)	141 (D)	123 (D)	126 (D)	130 (D)	364%	-8%
199-N-46	--	13.6 (C)	21.0 (D)	13.3 (D)	15.3 (D)	NC	13%
199-N-50	27 (D)	73 (D)	--	--	73.7 (D)	173%	1%
199-N-51	37 (D)	--	--	--	46.8 (D)	26%	NC
199-N-56	--	--	111 (D)	119 (D)	112 (D)	NC	NC
199-N-57	230 (D)	112 (D)	114 (D)	113 (D)	119 (D)	-48%	6%
199-N-64	160 (D)	104 (D)	119 (D)	133 (D)	102 (D)	-36%	-2%
199-N-67	17 (D)	62.2 (D)	55.3 (D)	50.3 (D)	77.3 (D)	335%	24%
199-N-69	20 (D)	--	--	--	66 (D)	230%	NC

Table 4-9. Sulfate Concentrations in Monitoring Wells and Aquifer Tubes

Well/Tube Name	Before P&T, Fall 1994 (pCi/L)	During P&T, Fall 2005 (pCi/L)	P&T in Cold-Standby Status, 2008	P&T in Cold-Standby Status, 2009	P&T in Cold-Standby Status, 2010	% Change 1994 to 2010	% Change 2005 to 2010
199-N-70 <sup>b</sup>	43(D)	70.3 (D)	71.8 (D)	68.8 (D)	--	60% <sup>a</sup>	-2% <sup>a</sup>
100-N-71	26 (D)	56.6 (C,D)	85 (D) <sup>d</sup>	94.6 (D)	87.8 (D)	238%	55%
199-N-72	69 (D)	119 (C,D)	---	131 (D)	123 (D)	78%	3%
199-N-74	100 (D)	67.5 (D)	78.7 (D)	79.4 (D)	85.2 (D)	-15%	26%
199-N-75 <sup>c</sup>	16 (D)	41.1 (D)	99.6 (D)	120 (D)	87.4 (D)	446%	113%
199-N-76	46 (D)	54.4 (D)	79.2 (D)	81.4 (D)	86.3 (D)	88%	59%
199-N-80 <sup>b</sup>	47 (D)	51.9 (D)	54.1 (D)	53.2 (D)	55.6 (D)	18%	7%
199-N-81	47 (D)	73 (D)	72.7 (D)	75.2 (D)	77.6 (D)	65%	6%
199-N-92A	--	35.2 (D)	45.2 (D)	45.7 (D)	49.8 (D)	NC	41%
199-N-96A	--	106 (C,D)	77.9 (D)	75.8 (D)	69.2 (D)	NC	-35%
199-N-99A	--	11.6 (C,D)	20 (D)	42.1 (D)	63.6 (D)	NC	448%
199-N-103A <sup>c</sup>	13 <sup>c</sup>	87.2	59.4 (D)	58.3 (D)	60.5 (D)	348%	-33%
199-N-105A <sup>c</sup>	17.2 <sup>c</sup>	66 (D)	77.1 (D)	86.5 (D)	105 (D)	510%	59%
199-N-106A <sup>c</sup>	18.9 <sup>c</sup>	62.5 (D)	70.1 (D)	67.7 (D)	68.4 (D)	262%	9%
199-N-119	--	8.2 (C)	12.2 (D)	11.3 (D)	13 (D)	NC	59%
199-N-120 <sup>b</sup>	--	10.6 (C)	52.6 (D)	--	49.6 (D)	NC	368%
199-N-121 <sup>b</sup>	--	25 (C,D)	132 (D)	--	76.9 (D)	NC	208%
199-N-122	--	9.2	55.1 (D)	10.6 (D)	46.7 (D)	NC	408%
199-N-123	--	12.9	15.2 (D)	12.8 (D)	28.1 (D)	NC	118%
199-N-146	--	7.10	27.5 (D)	11.2 (D)	20.5 (D)	NC	189%
199-N-147	--	6.8	37.8 (D)	10.6 (D)	17.7 (D)	NC	160%

Table 4-9. Sulfate Concentrations in Monitoring Wells and Aquifer Tubes

Well/Tube Name	Before P&T, Fall 1994 (pCi/L)	During P&T, Fall 2005 (pCi/L)	P&T in Cold-Standby Status, 2008	P&T in Cold-Standby Status, 2009	P&T in Cold-Standby Status, 2010	% Change 1994 to 2010	% Change 2005 to 2010
199-N-165	--	--	--	164 (D)	161 (D)	NC	NC
199-N-173	--	--	--	81.8 (D)	74.7 (D)	NC	NC
116m Array 3A	--	9.34	9.02 (B,D)	10.7 (D)	10.2 (D)	NC	9%
116m Array 4A	--	9.71	7.87 (B,D)	11.8 (D)	12.8 (D)	NC	32%
116m Array 6A	--	10.6	11.9 (D)	14.7 (D)	11.4 (D)	NC	8%
NVP2-116.0	--	14.7	10.7 (D)	10.8 (D)	9.76 (D)	NC	-34%

Notes:

1. Data from the fall of the year, unless otherwise noted.
  2. Orange-shaded cells show values above the secondary DWS (250 µg/L). Yellow-shaded cells show wells with values above the detection limit(s). Pink-shaded cells indicate increases in concentration since before P&T operations started and/or after P&T operations ceased.
    - a. Calculated percent change from 1994 to 2009 and 2005 to 2009 because no samples were collected in 2010.
    - b. Screened at depth in Ringold Formation.
    - c. Former P&T extraction well.
    - d. Not sampled in 2008; value from 2007 used for table.
    - e. Not sampled in 1994; value from 1995 used for table.
- B = analyte was detected at a value less than RDL, but greater than IDL/MDL  
 C = contaminant detected in quality control blank associated with sample  
 D = sample was diluted for analysis  
 N = spike sample outside limits  
 NC = not calculated because concentrations are too low or both numbers are nondetects  
 Q = associated with out-of-limit quality control data  
 U = undetected

**Table 4-10. Petroleum Hydrocarbon Removal from Well 199-N-18**

<b>Year</b>	<b>Product Removed (g)</b>	<b>Notes</b>
2003	~1,200 (see notes below)	Estimate provided per information given in note below; data records lost when original work package was lost in the field.
2004	3,475	Changed out twice a month.
2005	780	Changed approximately every 2 months.
2006	1,370	Changed every 2 months.
2007	1,294	Changed every 2 month.
2008	920	Changed every 2 months.
2009	1,380	Changed approximately every 2 months.
2010	225.5	Changed only twice prior to June 2010; smart sponge broke in well. No removal for second half of 2010.
<b>Total</b>		<b>10,644.5 g (~10.64 kg) total removed through end of 2010</b>

Notes:

1. The *Calendar Year 2003 Annual Summary Report for the 100-HR-3, 100-KR-4, and 100-NR-2 Operable Unit (OU) Pump & Treat Operations* (DOE/RL-2004-21) reports product removal started in October 2003.
2. The *Calendar Year 2004 Annual Summary Report for the 100-HR-3, 100-KR-4, and 100-NR-2 Operable Unit Pump-and-Treat Operations* (DOE/RL-2005-18) states that the average mass removal for fiscal year 2004 (October 2003 through October 2004) was approximately 0.4 kg/month, so an estimate is provided for the 3 months missing in calendar year 2003.

Table 4-11. Apatite PRB Sampling Points

Well Name	Well Type	Well Name	Well Type	Well Name	Well Type
199-N-122	MW	199-N-141	IB	199-N-156	MW-PT2 <sup>b</sup>
199-N-123	MW	199-N-142	IB	199-N-159	IB
199-N-126	MW-PT1 <sup>a</sup>	199-N-143	IB	199-N-160	IB
199-N-127	MW-PT1 <sup>a</sup>	199-N-144	IB	199-N-161	IB
199-N-128	MW-PT1 <sup>a</sup>	199-N-145	IB	199-N-162	IB
199-N-129	MW-PT1 <sup>a</sup>	199-N-146	MW	199-N-163	IB
199-N-130	MW-PT1 <sup>a</sup>	199-N-147	MW	199-N-164	IB
199-N-131	MW-PT1 <sup>a</sup>	199-N-148	MW-PT2 <sup>b</sup>	APT-1	AT
199-N-132	MW-PT1 <sup>a</sup>	199-N-149	MW-PT2 <sup>b</sup>	APT-5	AT
199-N-133	MW-PT1 <sup>a</sup>	199-N-150	MW-PT2 <sup>b</sup>	Array 2A-116.0	AT
199-N-136	IB	199-N-151	MW-PT2 <sup>b</sup>	Array 3A-116.0	AT
199-N-137	IB	199-N-152	MW-PT2 <sup>b</sup>	Array 4A-116.0	AT
199-N-138	IB	199-N-153	MW-PT2 <sup>b</sup>	Array 6A-116.0	AT
199-N-139	IB	199-N-154	MW-PT2 <sup>b</sup>	Array 7A-116.0	AT
199-N-140	IB	199-N-155	MW-PT2 <sup>b</sup>	NVP2-116.0	AT

a. PT1 = pilot test 1 site.

b. PT2 = pilot test 2 site.

ATA = aquifer tube

IB = injection/barrier well

MW = monitoring well

**Table 4-12. Apatite PRB Expansion Wells**

<b>Well Name</b>	<b>Well ID</b>	<b>Purpose</b>	<b>Well Name</b>	<b>Well ID</b>	<b>Purpose</b>	<b>Well Name</b>	<b>Well ID</b>	<b>Purpose</b>
199-N-200	C7327	IW shallow	199-N-257	C7350	IW shallow	199-N-314	C7407	IW deep
199-N-201	C7326	IW deep	199-N-258	C7351	IW deep	199-N-315	C7408	IW shallow
199-N-202	C7325	IW shallow	199-N-259	C7352	IW shallow	199-N-316	C7409	IW deep
199-N-203	C7324	IW deep	199-N-260	C7353	IW deep	199-N-317	C7410	IW shallow
199-N-204	C7323	IW shallow	199-N-261	C7354	IW shallow	199-N-318	C7411	IW deep
199-N-205	C7322	IW deep	199-N-262	C7355	IW deep	199-N-319	C7412	IW shallow
199-N-206	C7321	IW shallow	199-N-263	C7356	IW shallow	199-N-320	C7413	IW deep
199-N-207	C7320	IW deep	199-N-264	C7357	IW deep	199-N-321	C7414	IW shallow
199-N-208	C7319	IW shallow	199-N-265	C7358	IW shallow	199-N-322	C7415	IW deep
199-N-209	C7318	IW deep	199-N-266	C7359	IW deep	199-N-323	C7416	IW shallow
199-N-210	C7317	IW shallow	199-N-267	C7360	IW shallow	199-N-324	C7417	IW deep
199-N-211	C7316	IW deep	199-N-268	C7361	IW deep	199-N-325	C7418	IW shallow
199-N-212	C7315	IW shallow	199-N-269	C7362	IW shallow	199-N-326	C7419	IW deep
199-N-213	C7314	IW deep	199-N-270	C7363	IW deep	199-N-327	C7420	IW shallow
199-N-214	C7313	IW shallow	199-N-271	C7364	IW shallow	199-N-328	C7421	IW deep
199-N-215	C7312	IW deep	199-N-272	C7365	IW deep	199-N-329	C7422	IW shallow
199-N-216	C7311	IW shallow	199-N-273	C7366	IW shallow	199-N-330	C7423	IW deep
199-N-217	C7310	IW deep-core	199-N-274	C7367	IW deep	199-N-331	C7424	IW shallow
199-N-218	C7309	IW shallow	199-N-275	C7368	IW shallow	199-N-332	C7425	IW deep
199-N-219	C7308	IW deep-core	199-N-276	C7369	IW deep	199-N-333	C7426	IW shallow
199-N-220	C7307	IW shallow-core	199-N-277	C7370	IW shallow	199-N-334	C7427	IW deep

**Table 4-12. Apatite PRB Expansion Wells**

Well Name	Well ID	Purpose	Well Name	Well ID	Purpose	Well Name	Well ID	Purpose
199-N-221	C7306	IW deep	199-N-278	C7371	IW deep	199-N-335	C7428	IW shallow
199-N-222	C7305	IW shallow-core	199-N-279	C7372	IW shallow	199-N-336	C7429	IW deep
199-N-223	C7304	IW deep	199-N-280	C7373	IW deep	199-N-337	C7430	IW shallow
199-N-224	C7303	IW shallow	199-N-281	C7374	IW shallow	199-N-338	C7431	IW deep
199-N-225	C7302	IW deep	199-N-282	C7375	IW deep	199-N-339	C7432	IW shallow
199-N-226	C7301	IW shallow	199-N-283	C7376	IW shallow	199-N-340	C7433	IW deep
199-N-227	C7300	IW deep	199-N-284	C7377	IW deep	199-N-341	C7434	IW shallow
199-N-228	C7299	IW shallow	199-N-285	C7378	IW shallow	199-N-342	C7435	IW deep
199-N-229	C7298	IW deep	199-N-286	C7379	IW deep	199-N-343	C7436	IW shallow
199-N-230	C7297	IW shallow	199-N-287	C7380	IW shallow	199-N-344	C7437	IW deep
199-N-231	C7296	IW deep	199-N-288	C7381	IW deep	199-N-345	C7438	IW shallow
199-N-232	C7295	IW shallow	199-N-289	C7382	IW shallow	199-N-346	C7442	MW deep
199-N-233	C7294	IW deep	199-N-290	C7383	IW deep	199-N-347	C7441	MW deep
199-N-234	C7293	IW shallow	199-N-291	C7384	IW shallow	199-N-348	C7440	MW deep
199-N-235	C7328	IW shallow	199-N-292	C7385	IW deep	199-N-349	C7439	MW deep
199-N-236	C7329	IW deep	199-N-293	C7386	IW shallow	199-N-350	C7443	MW deep
199-N-237	C7330	IW shallow	199-N-294	C7387	IW deep	199-N-351	C7444	MW deep
199-N-238	C7331	IW deep	199-N-295	C7388	IW shallow	199-N-352	C7445	MW deep
199-N-239	C7332	IW shallow	199-N-296	C7389	IW deep	199-N-353	C7446	MW deep
199-N-240	C7333	IW deep	199-N-297	C7390	IW shallow	199-N-354	C7447	MW deep
199-N-241	C7334	IW shallow	199-N-298	C7391	IW deep	199-N-355	C7448	MW deep

Table 4-12. Apatite PRB Expansion Wells

Well Name	Well ID	Purpose	Well Name	Well ID	Purpose	Well Name	Well ID	Purpose
199-N-242	C7335	IW deep	199-N-299	C7392	IW shallow	199-N-356	C7449	MW deep
199-N-243	C7336	IW shallow	199-N-300	C7393	IW deep	199-N-357	C7450	MW deep
199-N-244	C7337	IW deep	199-N-301	C7394	IW shallow	199-N-358	C7451	MW deep
199-N-245	C7338	IW shallow	199-N-302	C7395	IW deep	199-N-359	C7452	MW deep
199-N-246	C7339	IW deep	199-N-303	C7396	IW shallow	199-N-360	C7453	MW deep
199-N-247	C7340	IW shallow	199-N-304	C7397	IW deep	199-N-361	C7454	MW deep
199-N-248	C7341	IW deep	199-N-305	C7398	IW shallow	199-N-362	C7455	MW deep
199-N-249	C7342	IW shallow	199-N-306	C7399	IW deep	199-N-363	C7456	MW deep
199-N-250	C7343	IW deep	199-N-307	C7400	IW shallow	199-N-364	C7457	MW deep
199-N-251	C7344	IW shallow	199-N-308	C7401	IW deep	199-N-365	C7458	MW deep
199-N-252	C7345	IW deep	199-N-309	C7402	IW shallow	199-N-366	C7459	MW deep
199-N-253	C7346	IW shallow	199-N-310	C7403	IW deep	199-N-367	C7463	MW deep
199-N-254	C7347	IW deep	199-N-311	C7404	IW shallow	199-N-368	C7460	MW deep-core
199-N-255	C7348	IW shallow	199-N-312	C7405	IW deep	199-N-369	C7461	MW deep-core
199-N-256	C7349	IW deep	199-N-313	C7406	IW shallow	199-N-370	C7462	MW deep-core

## Notes:

1. "Shallow" refers to 15 ft completion (Hanford formation).
2. "Deep" refers to 25 ft completion (Ringold Formation).
3. "Core" refers to when well was drilled, core was collected. All core wells were drilled to 25 ft but were completed at whatever depth the well was planned (i.e., two shallow wells were drilled as 25 ft core wells but were completed at 15 ft).

IW = injection well

MW = monitoring well

**Table 4-13. TPH Groundwater Results for Well 199-N-173**

<b>Date (Depth)</b>	<b>TPH-Diesel Range (µg/L)</b>	<b>TPH-Kerosene Range (µg/L)</b>
2/3/09 (7.01 m)	4,300/3,900	70 (U)/70 (U)
2/3/09 (7.07 m)	2,300	70 (U)
2/4/09 (10.06 m)	70 (U)	70 (U)
2/9/09 (13.11 m)	70 (U)	70 (U)
8/19/09	1,900	--
9/16/09	2,100	--
9/15/10	4,700 (F)/2,100	--

F = result is undergoing further review (may not be a valid number)

U = nondetect

**Table 4-14. TPH Soil Results for Well 199-N-173**

<b>Date</b>	<b>Interval (ft range)</b>	<b>Depth, m (ft)</b>	<b>Result TPD-DR (µg/L)</b>
1/29/09	I2-SS (9 to 12 ft)	3.34 m	3,100 (U)
2/2/09	I4-SS (12.5 to 14.5 ft)	4.12 m	59,000
2/2/09	I7-SS (15 to 16.5 ft)	4.80 m	59,000
2/2/09	I7D-SS (15 to 16.5 ft)	4.80 m	64,000
2/2/09	I9-SS (17.5 to 20 ft)	5.72 m	140,000
2/3/09	I14-SS (24.5 to 27 ft)	7.77 m	3,200 (U)
2/4/09	I18-SS (30 to 31.5 ft)	9.37 m	3,700 (U)
2/5/09	I21-SS (34.5 to 37 ft)	10.90 m	3,800 (U)
2/5/09	I25-SS (39.5 to 42 ft)	12.42 m	3,300 (U)
2/5/09	I28-SS (44.6 to 47.1 ft)	13.98 m	3,400 (U)

Notes: Interval range is from sample paperwork and is given in "ft"; sample depth is given in "m" within that range.

D = duplicate sample

SS = split-spoon sample

U = nondetect

**Table 4-15. WCH Bioventing Study Wells**

<b>Well Name</b>	<b>Well ID</b>	<b>Well Completion – Screen, m (ft)</b>
199-N-166	C7031	SV: 2.90 – 9.00 m (9.53 – 29.54 ft)
199-N-167	C7032	DV-GW: 16.13 – 23.73 m (52.91 – 77.86 ft)
199-N-168	C7033	SV: 2.97 – 9.07 m (9.75 – 29.75 ft)
199-N-169	C7034	DV-GW: 16.30 – 23.90 m (53.47 – 78.4 ft)
199-N-170	C7035	DV-GW: 16.72 – 24.34 m (54.87 – 79.84 ft)
199-N-171	C7036	DV-GW: 16.70 – 24.29 m (54.79 – 79.68 ft)
199-N-172	C7037	DV-GW: 17.43 – 23.51 m (57.17 – 77.14 ft)

DV-GW = deep vadose-groundwater completion

SV = shallow vadose completion

**Table 4-16. TPH-Diesel Range Results from WCH Wells**

<b>Date</b>	<b>199-N-167</b>	<b>199-N-169</b>	<b>199-N-170</b>	<b>199-N-171</b>	<b>199-N-172</b>
8/20/09	3,100	---	---	---	2,400
9/16/09	1,900	---	---	---	2,200 (D)
4/23/10	4,600 (N)	1,100 (N)	360 (N)	2,800 (N)	25,000 (DN)

D = analyte reported at a secondary dilution factor

N = spike or spike duplicate is outside control limits

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## 5 Pump-and-Treat System Cost Data

The actual costs for the 100-HR-3 and 100-KR-4 OU P&T systems for CY 2010 are presented in Sections 5.1 and 5.2, respectively. Section 5.3 addresses the 100-NR-2 OU and the cost breakdown for apatite PRB and related technology tests. The primary categories of expenditures are briefly described below:

- **Capital design:** Includes design activities to construct the P&T systems and designs for major system upgrades and modifications.
- **Capital construction:** Includes oversight labor, material, and subcontractor fees for capital equipment, initial construction, construction of new wells, redevelopment of existing wells, and modifications to the P&T system.
- **Project support:** Includes project coordination-related activities and technical consultation as required during the course of the facility design, construction, acceptance testing, and operation.
- **Operations and maintenance:** Represents facility supplies, labor, and craft supervision costs associated with operating the facility. It also includes the costs associated with routine field screening and engineering support as required during the course of P&T operation and periodic maintenance.
- **Performance monitoring:** Includes system and groundwater sampling and sample analysis, as required in accordance with the 100-HR-3 and 100-KR-4 OU interim action work plan (DOE/RL-96-84).
- **Waste management:** Includes the cost for the management of spent resin at the 100-HR-3 and 100-KR-4 OUs in accordance with applicable laws for suspect hazardous, toxic, and regulated wastes. Cost includes waste designation sampling and analysis. Also included are resin regeneration costs and new resin purchase.

Costs are burdened and are based on actual operating costs incurred during CY 2010. Summaries of the costs for each P&T system are presented in the following sections.

### 5.1 100-HR-3 Operable Unit Pump-and-Treat Systems Costs

In CY 2010, the 100-HR-3 OU accumulated various costs associated with four P&T systems (e.g., HR-3, DR-5, DX, and HX). The cost breakdowns for the 100-HR-3 OU P&T systems are shown in Tables 5-1 through 5-4 and Figures 5-1 through 5-4. Note that the HR-3 and DR-5 P&T systems mainly operated during CY 2010; however, the DX system was under construction for much of CY 2010 but came online in December 2010. The HX system was under construction in CY 2010 and was not operating. The costs reported for 2010 are the first year that costs have been reported on a CY basis. To make the transition from a FY to CY basis, the cost breakdown for 2009 consisted of the 15-month period from October 2008 through December 2009.

The cost breakdown for the HR-3 system for CY 2010 indicates that the majority of the costs, in decreasing order, were charged to operations and maintenance (75 percent), performance monitoring (13 percent), project support (7 percent), waste management (4 percent), and design (1 percent).

The cost breakdown for the DR-5 system for CY 2010 indicates that the majority of the costs, in decreasing order, were charged to operations and maintenance (69 percent), performance monitoring (18 percent), project support (11 percent), and waste management (2 percent).

The cost breakdown for the DX system for CY 2010 indicates that the majority of the costs, in decreasing order, were charged to capital construction (86 percent), project support (7 percent), and design (7 percent).

The cost breakdown for the HX system for CY 2010 indicates that the majority of the costs, in decreasing order, were charged to capital construction (86 percent), design (10 percent), and project support (7 percent).

## **5.2 100-KR-4 Operable Unit Pump-and-Treat Systems Costs**

In this report, the costs associated with each of the three 100-KR-4 OU P&T systems (KR4, KX, and KW) have been reported on a CY basis (Tables 5-5 through 5-7). In previous years, however, the annual costs of the P&T systems at the 100-KR-4 OU were reported on a FY basis. To make the transition from a FY to CY basis, the 2009 cost breakdowns for the KR4 and KW systems were calculated for the 15-month period from October 2008 through December 2009. CY 2010 was the first full operational year for the KX system, and the construction and other costs accrued by this system during 2009 were included as part of KR4 system costs for 2009.

### **5.2.1 KR4 Pump-and-Treat System**

The cost breakdown for the KR4 P&T system from 1999 through 2010 is shown in Table 5-5 and Figure 5-5. The total costs reported for the 12-month period reported for CY 2010 are substantially lower than the total costs reported for the 15-month period reported for CY 2009 (even when 2009 is normalized to a 12-month basis) and for the 12-month period of FY 2008 (Table 5-5). The total cost for the KR4 system during CY 2010 (\$6.92 million) consists of the sum of the categories shown in Table 5-5. The percentage that each category comprises of the total cost for the KR4 system is illustrated in Figure 5-5 and is as follows, in decreasing order: treatment system capital construction (51.4 percent); operations and maintenance (20.5 percent), performance monitoring (13.4 percent), project support (1.1 percent), waste management (3.9 percent), and design (0.4 percent).

Although the capital costs during CY 2010 were substantial, the capital costs for the KR4 system for CY 2010 were substantially lower than in 2008 and 2009. The lower total costs of the KR4 system during CY 2010 is due primarily to the extensive modifications to this system and to the costs of KX system construction included as part of the KR4 system costs in 2009.

### **5.2.2 KX Pump-and-Treat System**

The total cost for the KX P&T system for CY 2010 (the first full operational year) was \$2.46 million (Table 5-6). The largest single component of the total cost was the \$1.22 million spent during the year for operations and maintenance. Waste management and performance monitoring followed at approximately \$0.58 and \$0.53 million, respectively (Table 5-6). Figure 5-6 presents the cost accrued under each cost category as a percentage of the total. Design cost represented approximately 49.7 percent of the total costs accrued during CY 2010, with waste management and performance monitoring combined at 45 percent of the total cost. Project support, design costs, and capital construction comprised the remaining 5.3 percent of the total cost.

### **5.2.3 KW Pump-and-Treat System**

The cost breakdown for the first year of the KW P&T system is presented in Table 5-7 and Figure 5-7. The total CY 2010 construction and operation cost was \$3,137,200. The FY 2007 cost breakdown indicated that the majority of the cost was for treatment system capital construction (69.7 percent), followed, in decreasing order, by waste management (12.9 percent), operations and maintenance (12.8 percent), design (0.4 percent), and performance monitoring (0.3 percent). Based on the total

FY 2007 cost of \$3,137,200, the yearly production rate of 172.5 million L (45.5 million gal), and 21.1 kg of hexavalent chromium removed, the annual treatment costs equate to \$0.018/L, or \$149/g, of hexavalent chromium removed.

The cost breakdown for the KW P&T system in 2007 through 2010 is presented in Table 5-7. The total CY 2010 cost was \$2,603,000. This is a substantial reduction relative to 2009 primarily due to a substantial decrease in capital construction costs.

Figure 5-7 indicates that the largest fraction (50 percent) of the CY 2010 cost was related to operation and maintenance of the system. Performance monitoring contributed 31 percent of the total costs, followed (in decreasing order) by capital construction (12 percent), project support (5 percent), and waste management (2 percent).

### **5.3 100-NR-2 Pump-and-Treat System Costs**

The cost breakdown for CY 2010 for the apatite PRB and related technology tests (replacement for P&T at the 100-N Area) is presented in Table 5-8 and Figure 5-8. The total CY 2010 construction and operation costs were \$3,984,000. The FY 2010 cost breakdown indicates that the majority of the cost was for barrier maintenance (36.85 percent), followed, in decreasing order, by field studies (30.83 percent), performance monitoring (24.00 percent), project support (6.94 percent), design (0.78 percent), operations and maintenance (0.59 percent), waste management (0.01 percent), and treatment system capital construction (less than 0.00 percent).

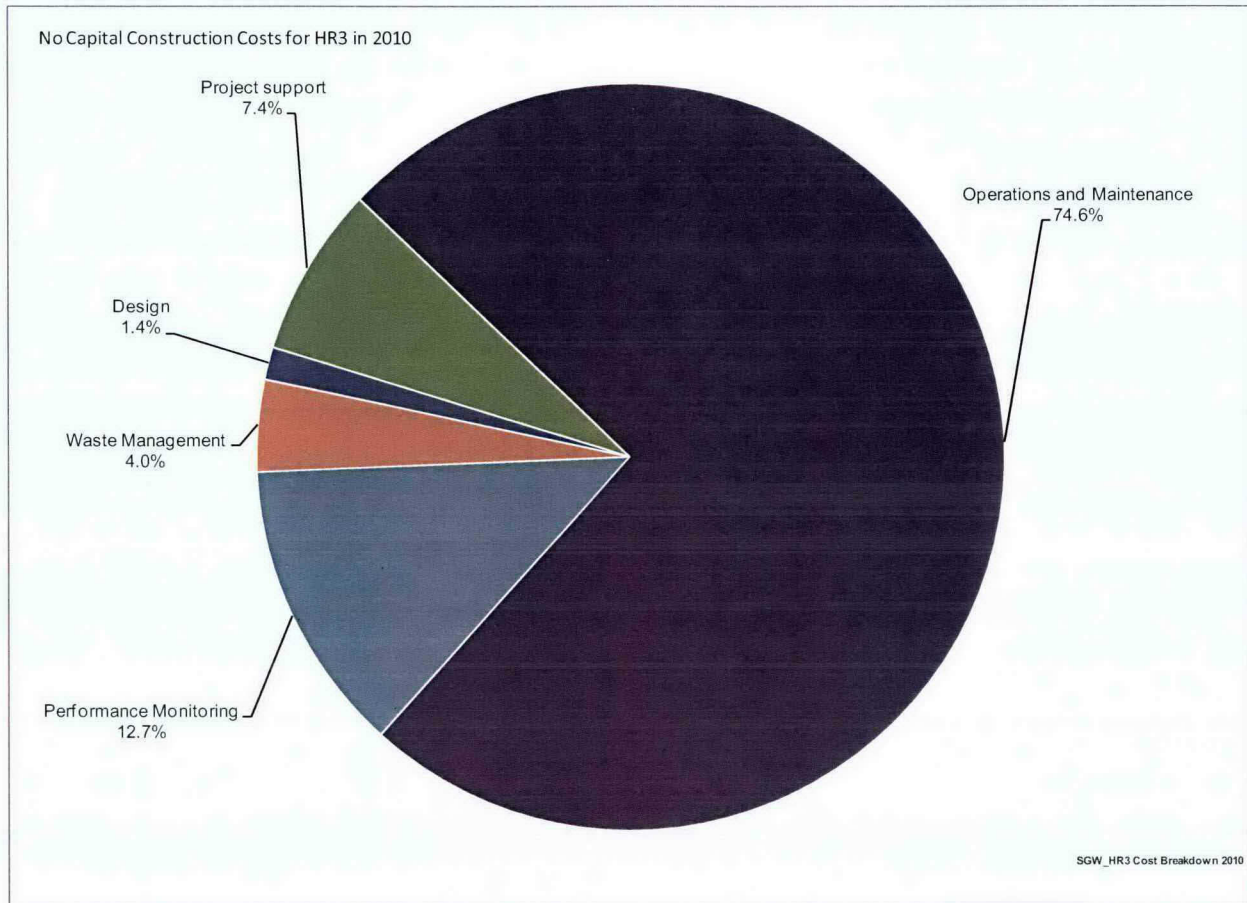


Figure 5-1. HR-3 P&T System, CY 2010 Cost Breakdown (by Percentage)

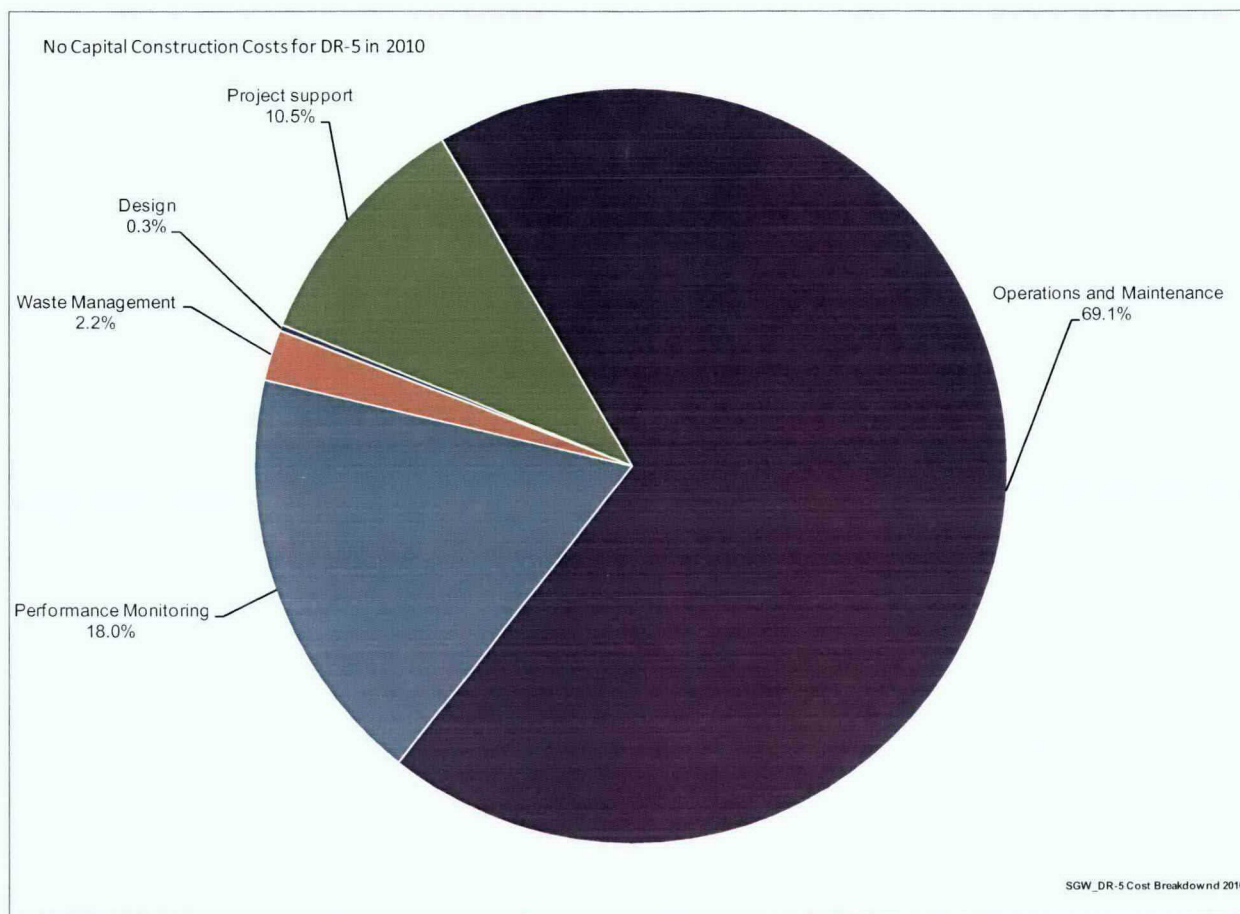


Figure 5-2. DR-5 P&T System, CY 2010 Cost Breakdown (by Percentage)

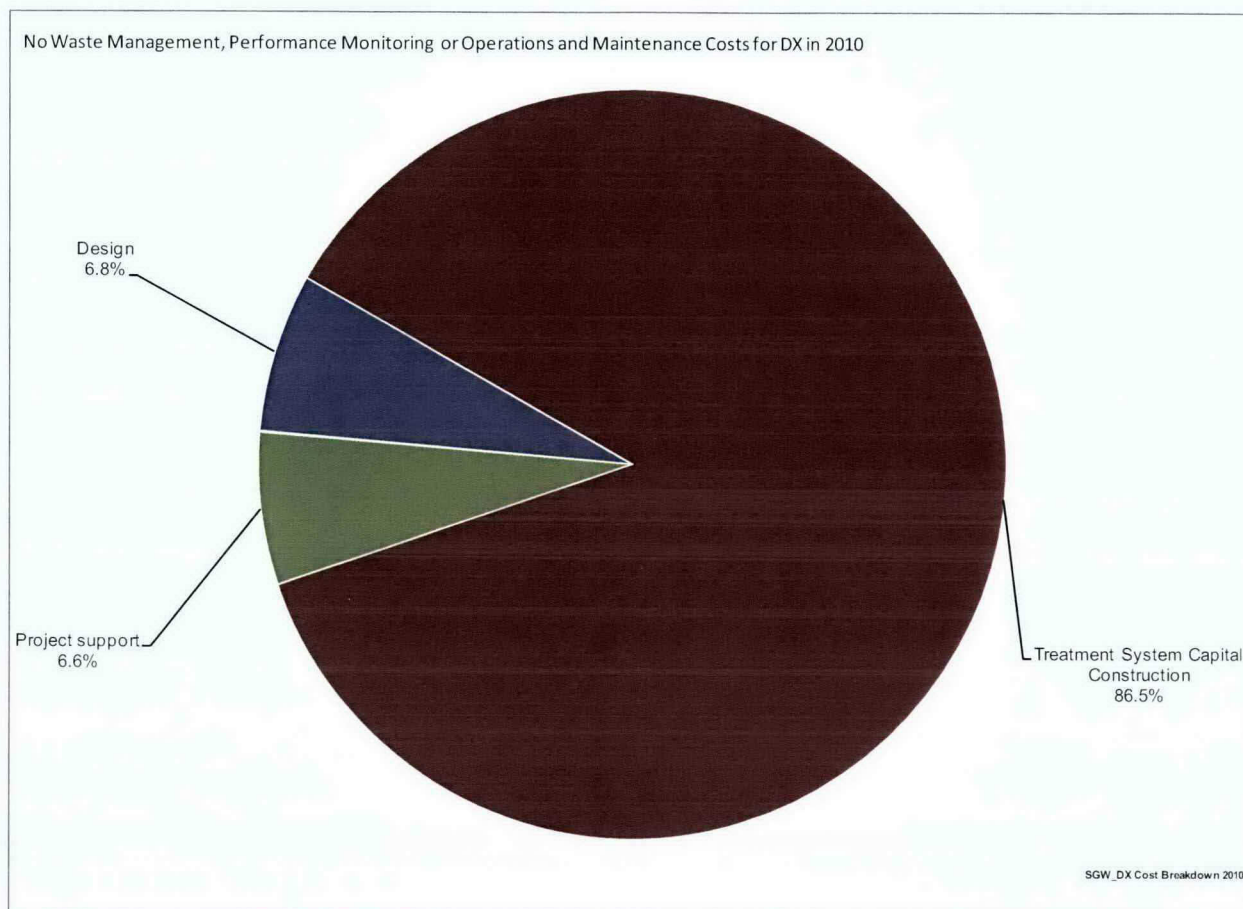


Figure 5-3. DX P&T System, CY 2010 Cost Breakdown (by Percentage)

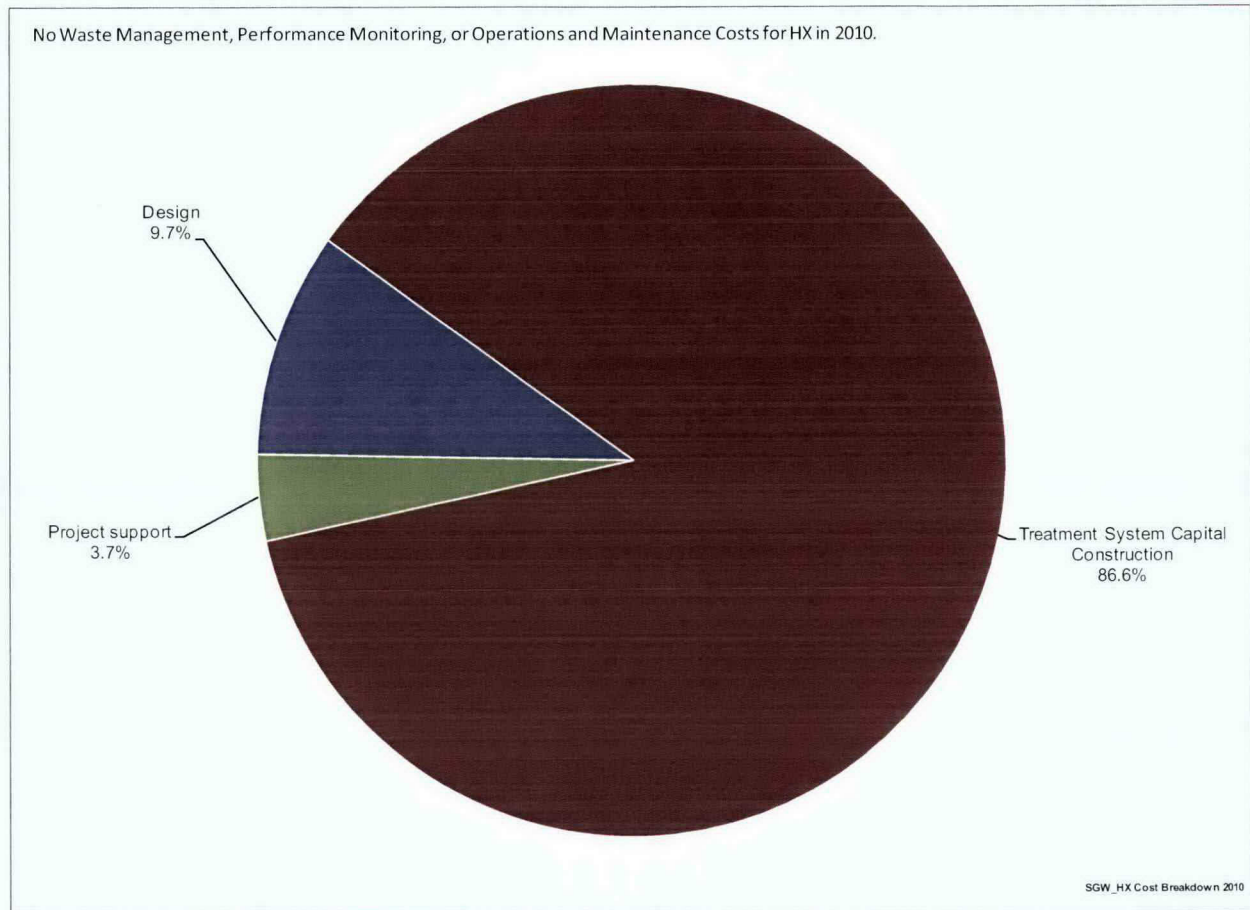


Figure 5-4. HX P&T System, CY 2010 Cost Breakdown (by Percentage)

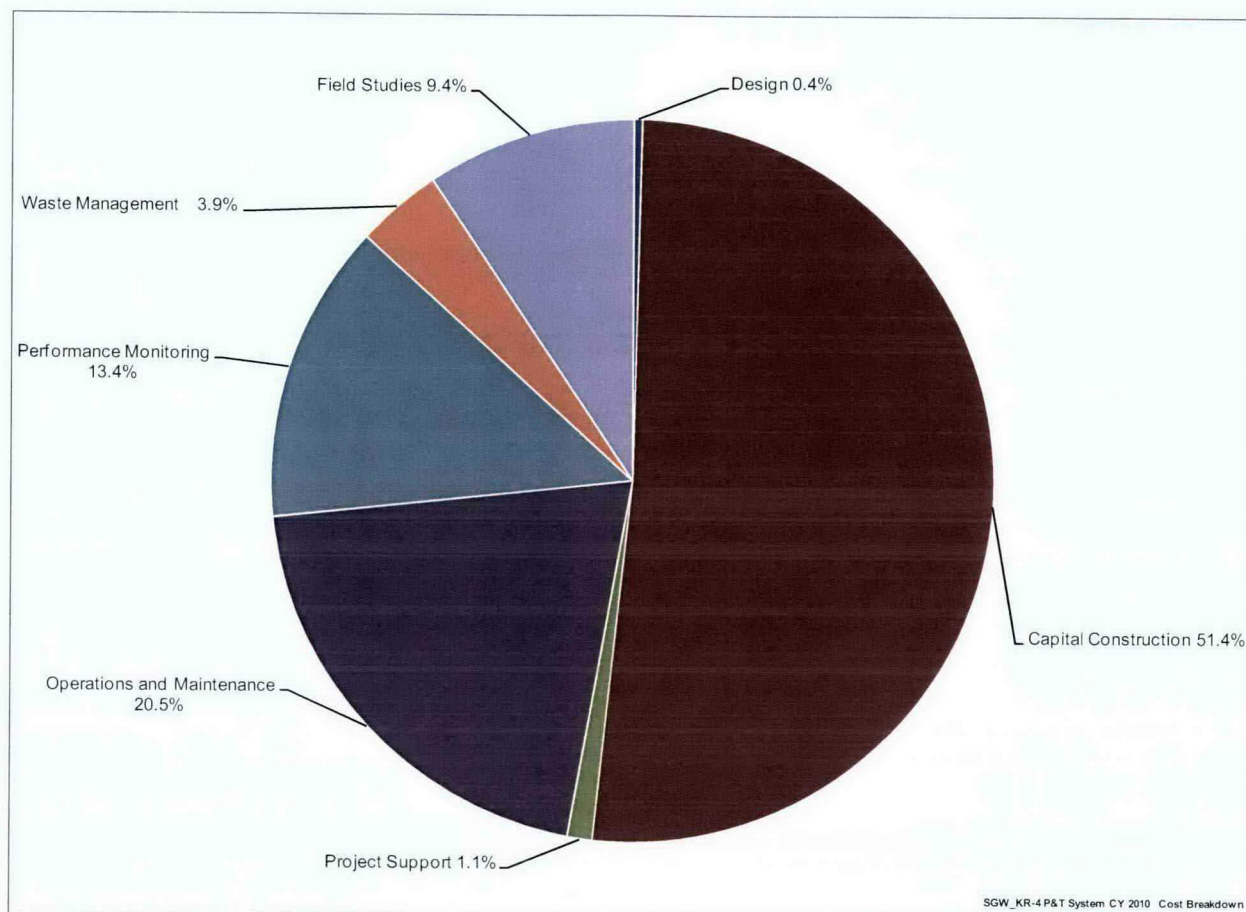


Figure 5-5. KR4 P&T System, CY 2010 Cost Breakdown (by Percentage)

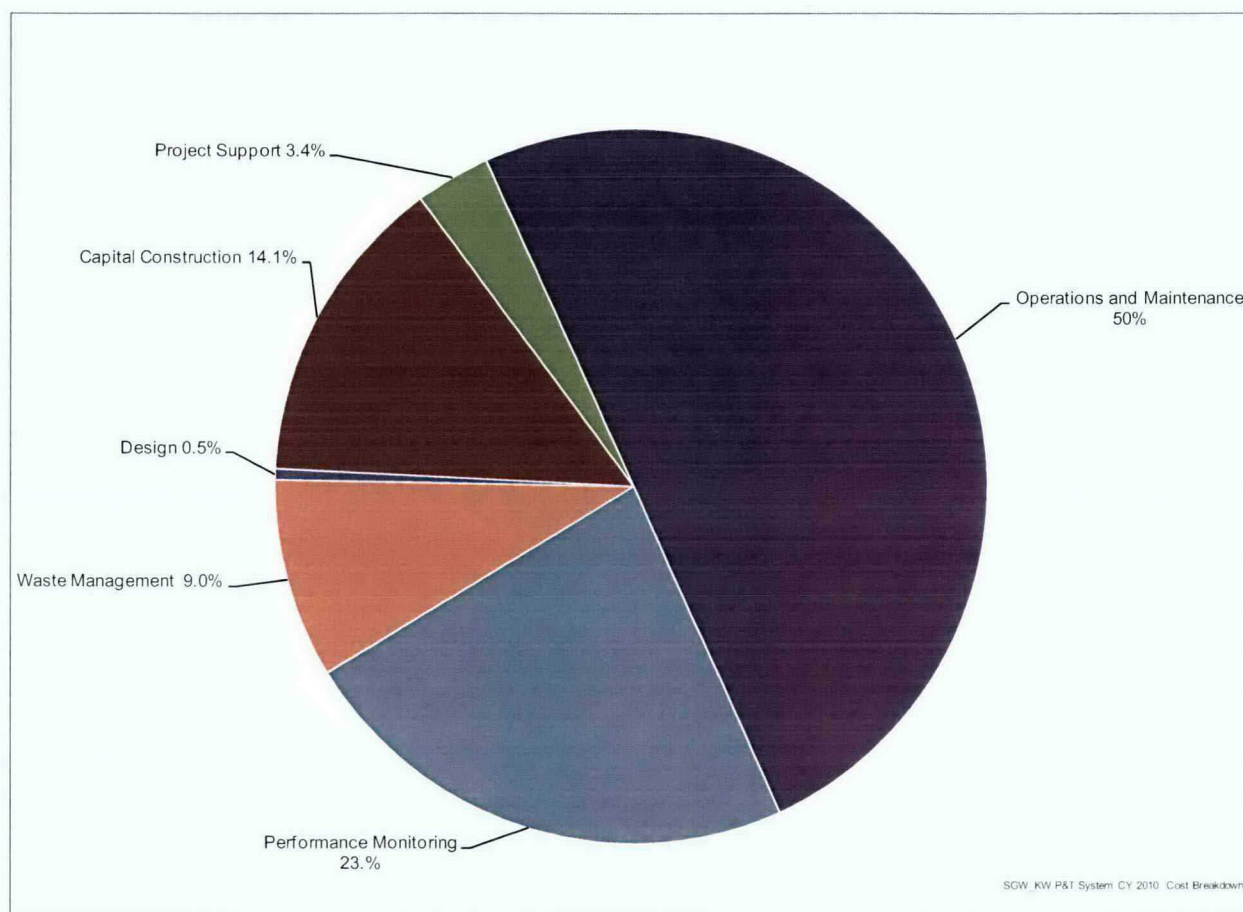


Figure 5-6. KW P&T System, CY 2010 Cost Breakdown (by Percentage)

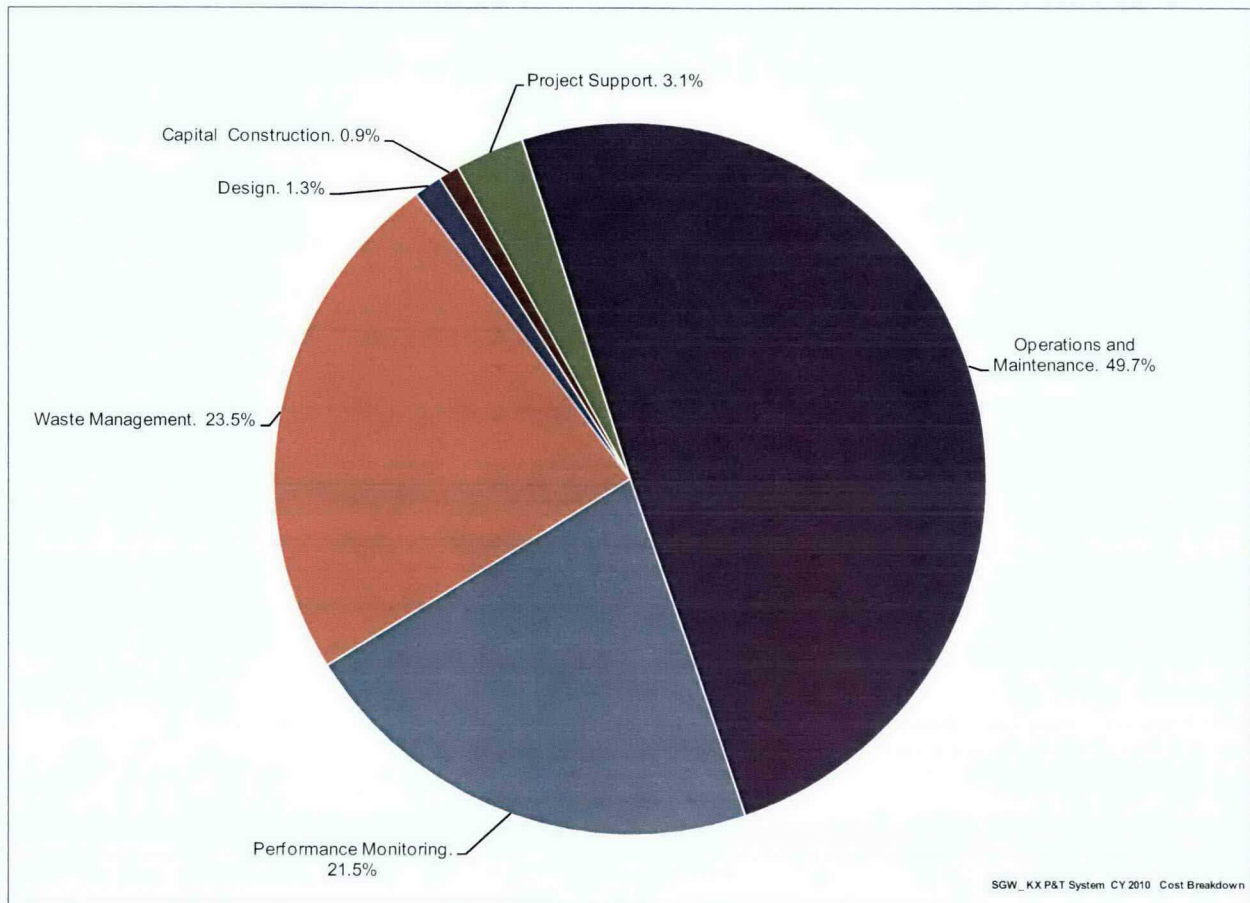


Figure 5-7. KX P&T System, CY 2010 Cost Breakdown (by Percentage)

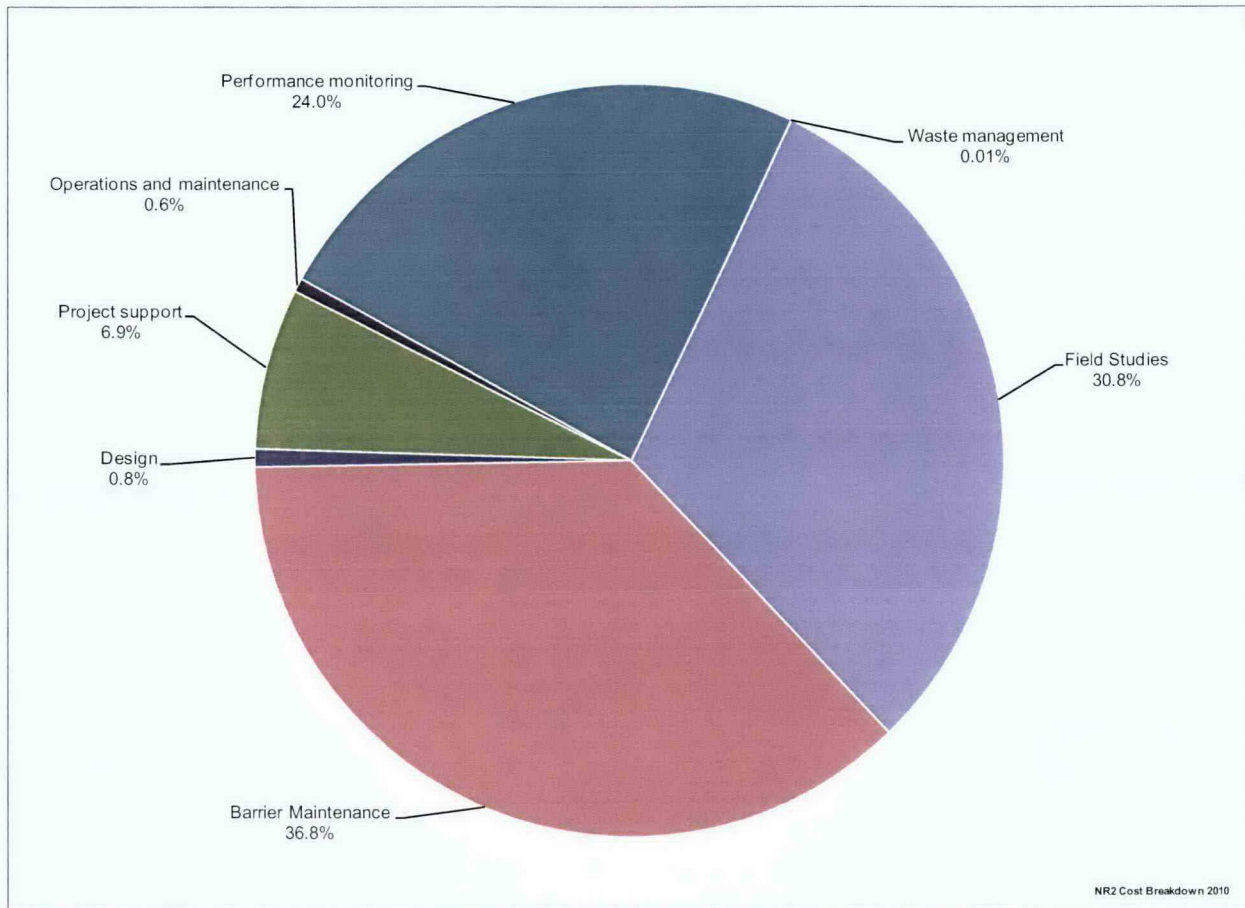


Figure 5-8. 100-NR-2 P&T System, CY 2010 Cost Breakdown (by Percentage)

Table 5-1. Breakdown of HR-3 P&amp;T System Construction and Operation Costs

Description	Actual Costs (Dollars x 1,000)											
	1999	2000	2001 <sup>a</sup>	2002 <sup>b</sup>	2003	2004	2005	2006	2007	2008	2009 <sup>f</sup>	2010
Design	--	--	97.7	15.4	8.1	196.1	196.0	55.0	92.0	--	0.0	26.5
Treatment system capital construction	--	57.7	(36.1)	750.3	--	496.6	10.0	--	--	--	--	--
Project support	265.3	276.7	225.8	309.3	229.8	211.8	722.6	697.6	171.9	169.5	204.7	139.6
Operations and maintenance	1,650.8	799.1	739.2	816.6	733.7	1,049.5	618.5	891.2	679.6	1,084.8	1,091.8	1,411.5
Performance monitoring	--	173.7	219.9	120.0	163.2	120.3	353.0	489.6	219.5	508.5	237.7	240.0
Waste management	--	895.3	424.9	720.1	877.2	501.7	202.2	217.6	434.7 <sup>c</sup>	192.2	16.6	75.0
<b>Totals</b>	<b>\$1,916</b>	<b>\$2,203</b>	<b>\$1,671</b>	<b>\$2,732</b>	<b>\$2,012</b>	<b>\$2,576</b>	<b>\$2,102</b>	<b>\$2,351</b>	<b>\$1,598</b>	<b>\$1,955</b>	<b>\$1,551</b>	<b>\$1,893</b>

a. 2001 costs corrected for project support and waste management. Initial expense calculations for 2001 were not properly categorized.

b. 2002 accrual costs corrected for appropriate split between Bechtel Hanford, Inc. and Fluor Hanford, Inc.

c. Additional design costs associated with P&T expansion.

d. Additional treatment system capital construction costs associated with new wells and buildings to support P&T expansion.

e. Additional costs associated with drilling wastes and resin cleared for shipment and handling.

f. Annual report has been transitioned from a FY reporting period to a CY reporting period. The cost breakdown for 2009 is for the 15-month period from October 2008 through December 2009.

-- = not available

**Table 5-2. Breakdown of DR-5 P&T System Construction and Operation Costs**

<b>Description</b>	<b>Actual Costs (Dollars x 1,000)</b>					
	<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>	<b>2009*</b>	<b>2010</b>
Design	246.9	196.8	100.4	--	3.2	3.4
Treatment system capital construction	--	22.2	--	--	--	--
Project support	586.4	370.6	240.3	233.6	204.7	139.6
Operations and maintenance	459.6	605.7	541.3	884.7	1,091.7	919.9
Performance monitoring	106.2	1.6	11.3	127.1	237.7	240.0
Waste management	28.3	154.7	45.4	23.8	1.7	29.0
<b>Totals</b>	<b>\$1,427</b>	<b>\$1,352</b>	<b>\$939</b>	<b>\$1,269</b>	<b>\$1,539</b>	<b>\$1,332</b>

\* Annual report has been transitioned from a FY reporting period to a CY reporting period. The cost breakdown for 2009 is for the 15-month period from October 2008 through December 2009.

**Table 5-3. Breakdown of DX P&T System Construction and Operation Costs**

<b>Description</b>	<b>Actual Costs (Dollars x 1,000)</b>	
	<b>2009*</b>	<b>2010</b>
Design	2,115.2	1,287.8
Treatment system capital construction	5,759.8	16,266.3
Project support	495.1	1,236.9
Operations and maintenance	--	--
Performance monitoring	--	--
Waste management	7.4	9.2
<b>Totals</b>	<b>\$8,377</b>	<b>\$18,800</b>

\* Annual report has been transitioned from a FY reporting period to a CY reporting period. The cost breakdown for 2009 is for the 15-month period from October 2008 through December 2009.

**Table 5-4. Breakdown of HX P&T System Construction Costs**

<b>Description</b>	<b>Actual Costs (Dollars x 1,000)</b>	
	<b>2009*</b>	<b>2010</b>
Design	896.4	1,047.5
Treatment system capital construction	214.1	9,354.2
Project support	--	400.2
Operations and maintenance	--	--
Performance monitoring	--	--
Waste management	--	0.1
<b>Totals</b>	<b>\$1,111</b>	<b>\$10,802</b>

\* Annual report has been transitioned from a FY reporting period to a CY reporting period. The cost breakdown for 2009 is for the 15-month period from October 2008 through December 2009.

Table 5-5. Breakdown of K4 P&amp;T System Construction and Operation Costs

Description	Actual Costs (Dollars x 1,000)											
	1999	2000	2001 <sup>a</sup>	2002 <sup>b</sup>	2003	2004	2005	2006	2007	2008	2009 <sup>f,g</sup>	2010
Design	0.2	--	96.5	55.2	70.8	163.9	190.8	97.8	187 <sup>c</sup>	63.1	157.7	25.4
Treatment system capital construction	--	109.1	(0.1)	860.1	379.9	94.2	273.8	1,505.8	2114.1 <sup>d</sup>	8,368.5	6651.0 <sup>d</sup>	3,556.2
Project support	157.2	143.0	188.2	257.8	171.0	211.8	851.9	530.5	489.8	963.0	174.1	77.6
Operations and maintenance	717.4	538.0	578.6	771.9	789.7	1,118.2	878.6	1,350.8	804.3	916.0	1,619.3	1,418.1
Performance monitoring	--	111.2	122.6	124.6	119.7	83.3	446.3	548.8	395.7	634.9	569.1	928.1
Waste management	--	481.8	367.5	343.3	684.7	475.8	198.3	230.2	458.9 <sup>e</sup>	438.2	599.8	266.7
Field studies	--	--	--	--	--	--	--	--	--	--	25.0	653.1
<b>Totals</b>	<b>\$875</b>	<b>\$1,383</b>	<b>\$1,353</b>	<b>\$2,413</b>	<b>\$2,216</b>	<b>\$2,147</b>	<b>\$2,840</b>	<b>\$4,264</b>	<b>\$4,450</b>	<b>\$11,384</b>	<b>\$9,796</b>	<b>\$6,925</b>

a. 2001 costs corrected for project support and waste management. Initial expense calculations for 2001 were not properly categorized.

b. 2002 accrual costs corrected for appropriate split between Bechtel Hanford, Inc. and Fluor Hanford, Inc.

c. Additional design costs associated with P&T expansion.

d. Additional treatment system capital construction costs associated with new wells and buildings to support P&T expansion.

e. Additional costs associated with drilling wastes and resin cleared for shipment and handling.

f. Annual report has been transitioned from a FY reporting period to a CY reporting period. The cost breakdown for 2009 is for the 15-month period from October 2008 through December 2009.

g. KX system costs prior to startup included in with 2009.

-- = not available

**Table 5-6. Breakdown of KX P&T System Costs**

<b>Description</b>	<b>Actual Costs (Dollars x 1,000)</b>
	<b>2010</b>
Design	31.4
Treatment system capital construction	22.9
Project support	77.6
Operations and maintenance	1,224.4
Performance monitoring	528.9
Waste management	579.6
Field studies	--
<b>Totals</b>	<b>\$2,465</b>

**Table 5-7. Breakdown of KW P&T System Costs**

<b>Description</b>	<b>Actual Costs (Dollars x 1,000)</b>			
	<b>2007</b>	<b>2008</b>	<b>2009<sup>a</sup></b>	<b>2010</b>
Design	13.0	27.7	78.1	11.6
Treatment system capital construction	2,187.8	1,088.3	2,301.8	324.3
Project support	118.9	155.3	174.1	77.6
Operations and maintenance	402.4	599.6	758.6	1,149.6
Performance monitoring	9.7	126.6	215.9	528.9
Waste management	405.4	164.3	95.4	207.5
Field studies	--	--	--	--
<b>Totals</b>	<b>\$3,137</b>	<b>\$2,162</b>	<b>\$3,624</b>	<b>\$2,300</b>

\* Annual report has been transitioned from a FY reporting period to a CY reporting period. The cost breakdown for 2009 is for the 15-month period from October 2008 through December 2009.

Table 5-8. Breakdown of 100-NR-2 P&amp;T System Construction and Operation Costs

Description	Actual Costs (Dollars x 1000)											
	1999	2000	2001 <sup>a</sup>	2002 <sup>b</sup>	2003	2004	2005	2006	2007	2008	2009	2010
Design	0.2	--	--	--	--	--	447.9	--	--	--	20.5	31.0
Treatment system capital construction	--	--	--	--	--	--	161.9	922.6	--	--	316.2	(0.1)
Project support	113.1	96.3	183.5	219.4	133.0	329.7	416.5	284.4	79.8	10.7	278.5	276.5
Operations and maintenance	657.4	462.2	631.5	631.8	604.3	553.0	650.6	592.6	199.9	107.4	50.2	23.6
Performance monitoring	--	82.6	83.1	72.4	51.6	79.6	408.7	182.2	62.7	36.2	466.2	956.3
Waste management	--	131.6	112.5	100.0	45.4	27.4	7.6	13.0	43.4	8.9	3.6	0.5
Field studies	--	--	--	--	--	--	--	--	--	--	874.1	1,228.3
Barrier maintenance	--	--	--	--	--	--	--	--	--	--	634.3	1,468.0
<b>Totals</b>	<b>\$771</b>	<b>\$773</b>	<b>\$1,011</b>	<b>\$1,024</b>	<b>\$834</b>	<b>\$990</b>	<b>\$2,093</b>	<b>\$1,995</b>	<b>\$386</b>	<b>\$163</b>	<b>\$2,644</b>	<b>\$3,984</b>

a. 2001 costs corrected for project support and waste management. Initial expense calculations for 2001 were not properly categorized.

b. 2002 accrual costs corrected for appropriate split between Bechtel Hanford, Inc. and Fluor Hanford, Inc.

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